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FRENCH ROADS, THEIR ADMINISTRATION, CONSTRUCTION AND MAINTENANCE.

BY PROF. FRANK H. NEFF, MEMBER OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read Nov. 10, 1891.]

The first great roads of France, as is indeed the case of other countries of Europe, were of Roman origin, and were built by them for the purpose of maintaining their military supremacy.

But the present great system of public highways, of which France may so justly be proud, is of much more recent origin, although not by any means of sudden growth, but rather the result of the experience and investigation of their best engineers for a century back.

As far back as the XIII century we find that they were already occupied with the classification of the then existing roads.

By degrees the lines separating different classes, which at first must have been more or less vague, became well defined, as roads were constructed to be of one class or another.

So to-day we find three distinct classes of roads:—

(1) National Roads (Routes Nationales.)

(2) Departmental Roads (Routes Departmentales.)

(3) Vicinal or County Roads (Chemin Vicinaux.)

The third class is again divided into three classes according as the roads are a means of communication between several large communes, join small ones only, or are a part of those belonging to a single commune.

A word about the general plan of government of France and the di-

vision of its territory may help to better understand the lay of the ground.

France is divided into 87 Departments, as they are called, governed by a prefect, who is appointed by the general government. He is assisted by a prefect council, and by subprefects who have the charge of Arrondissements.

These 87 Departments are divided into 362 Arrondissements, being about four (4) to a Department.

The Arrondissements are divided into 2365 cantons, about 8 cantons to each Arrondissement.

The cantons are again divided into communes, 36,074 in number or about 13 to a canton.

The total area of France is 204,000 sq. miles so that the average area of a commune is about $5\frac{3}{4}$ sq. miles.

The total population is about 38,000,000 so that the population of the communes will average about 1,000 people.

The National Roads are such as were built principally for military purposes. Their entire cost of construction and expense of maintenance are borne by the general government.

As France has changed her form of government from time to time, these roads have been successively called—Imperial, Royal, and National Roads. Their total length is about 24,000 miles.

The *Departmental Roads* compose a separate system in each department. They connect its principal cities and are designed with the best interests of that entire department in view.

They are opened, constructed and maintained at the expense of the department. They comprise altogether about 24,000 miles.

In the last but by many times the most important class, both from the extent and utility of the roads classed therein are the County Roads or *chemins vicinaux*. For naturally with the advent of railroads and the adoption of narrow gauge systems in the departments, as has been done there, the need of a means of transport for troops and merchandise at long distances, which called into existence National and Departmental roads, has been much better met by the railroad.

So that their growth has been of little importance since the invention of the latter. But as one might expect; just the opposite effect was produced upon the development of the local roads.

Increased, and cheaper transportation has brought hitherto inaccessible markets within reach and made good roads for reaching the railroads, a thing to be desired; so that these County or Vicinal roads have a length of about 368,000 miles: which does not include the roads within the limits of the villages.

These roads are built and maintained by the communes through which they run. A road joining two communes being owned and

maintained by each as far as their common boundary.

The familiar maxim of a "stitch in time" is characteristic of the system employed by the French in the maintenance of their roads.

It was in 1818 that this maxim was first used in connection with the maintenance of roads. At that time an inquiry was being made into methods, and a Mr. Walker in a speech said that "a stitch in time" was the maxim of all good housekeepers, and why not apply it to roads. Since then the principle of "a stitch in time" has been adopted by engineers to denote that system which means constant inspection and repair. You can see that the application of such a principle must require a staff of workers. To repair at once any degradation of the surface, or to remove at once any mud that may result from protracted bad weather, requires that workmen be distributed along the road to take the timely stitch.

The care of the National Roads is a large part of the duties of the "Engineers of Bridges and Roads" (Ingenieurs des Ponts et Chaussees) and belongs to the port-folio of the Minister of Public Works.

In each department, there is appointed by the Minister of Public Works, an *Engineer in Chief*, who has the direction and responsibility of the work of maintenance of such portion of the National roads as lie within that department. He is also placed in charge of some other work in that department. Either of railroads, navigation; either of canal or river improvements, or the care of the seaports if such lie in that department.

Sometimes he is also in charge of the Departmental Roads, and in a few cases, of the County roads as well; under him are several *Engineers in ordinary* (Ingenieurs Ordinaires) who are employed only in a certain section of the department. Each one having charge of the work in an Arrondissement.

There they direct the repairs according to the general plans of their chief, but at the same time they are allowed a considerable liberty to display their ability or originality, and follow out their own ideas in the details of the work. Their duties require them to visit carefully at least four times a year, oftener if necessary, every road confided to their care.

The next grade below the Engineers in ordinary is that of *Conductor or Asst. Engineer.*

The *Conductor* has a sub-division comprising a length such that he may be able to inspect it in detail at least twice each month and still have sufficient time to attend to the other requirements of the service with which the chief is charged—*i. e*, of Bridges—Railroads—Canals—Seaports, etc.

The subdivision comprises usually from 25-50 miles of road according to the distribution and the complexity of their maintenance, and

of other details connected with them. The Conductor makes as I have said, semi-monthly inspections of the roads under his charge—and further—he makes his tours of inspection on foot.

He gives orders to the foremen of the different gangs at work along the roads. He keeps a record of their work to see that they do a proper amount. If any have been guilty of neglect he may recommend to his chief that they be punished.

Following each regular inspection he forwards a written report to the engineer in charge of that division. He keeps the accounts for his division. He is consulted by the engineer in case of the receipt of any petition or other affairs, upon which his accurate knowledge of the division would make him capable of giving information or advice.

If any surveys are to be made, he makes them. He also inspects all road material, all of which is furnished by contract, and has immediate charge of the construction of all new work.

The Engineer can give no order to the laborers without giving it through the Conductor.

In districts where there is much to do the Conductor is aided by a Second Asst. Engineer.

This is the grade held by the younger Engineers, who have charge of the drafting and clerical work in the Chief Engineer's office and also assist in the out door work when there is a press of it.

It is from the ranks of these latter that by promotion the corps of Asst. Engineers or Conductors is kept up to the required number. Their promotion is made upon their successfully passing examinations for that purpose.

A word about the recruiting of the large staff of engineers needed where the government takes an active part in the construction and maintenance of roads, the inspection of mines, railways, etc., and even in the owning and running a large system of railways.

There are three schools to be mentioned in this connection.

The Polytechnic School, the National School of Mines, the National School of Bridges and Roads.

The Polytechnic receives Frenchmen only. They are given a regular technical education; many scholarships being awarded to students.

The forty highest of the graduates are permitted to go to, either the School of Mines, or School of Bridges and Roads, as they may elect, except that if there are more elect to go to the School of Mines than there are vacancies those with the lower grades are compelled to go to the other school.

Upon their entry into either one of these schools they receive a certain salary to enable them to pay their expenses during the three years necessary to complete the course in either institution.

During that time their conduct and grade must be above a certain standard, or they are liable to be discharged from service. For it amounts to that, that from the time they enter, they are upon the staff, of government engineers.

During vacations they are given practice, or an opportunity to study practice under the best engineers—and at the completion of the course they are given stations with a salary that varies with the cost of living in that department.

No engineer can bear the title of Engineer of Mines or Engineer of Bridges and Roads without being a graduate of one of these institutions.

The Professors in the schools are all past graduates of the same school and men who have risen to the grade of General Inspector, one between Engineer in Chief and Minister of Public Works.

They hold this position at the same time they are employed in the school. So that they are actively engaged in government work at the same time they are teaching.

Lectures begin the first of November and continue until May; so that about six months of each year is spent upon government work under able engineers.

A limited number only of student engineers, as they are called, are admitted into either school. Forty only each year into both. But besides these there are others who may follow the courses at the school. They are called Eleves Externes, external pupils, who have the same advantages within the school except a salary. That is they get free, everything necessary for their work.

Foreigners may be admitted into this class if sent by their governments.

From this class, Eleves Externes, I suppose that the trustees or commissioners of Departmental and County roads are chosen.

Foreigners, by simple application, are given a card which entitles them to attend the greater part of the lectures given to the students, but does not entitle them to the privilege of working in the laboratories or drawing rooms.

Under the Conductor comes the road laborer. The road laborers are divided into squads of five or six. Each one is in charge of an *overseer*, chosen from one of their number.

Each of the road laborers has charge of a length of road varying from 1¼ to 2½ miles depending upon the condition of the road, the amount of circulation, and the method of maintenance, which would depend upon the nature of its construction.

When there happens to be much work to be done at once, a few laborers by the day are hired to assist; but they are reduced to the least possible number.

If there is to be work that will require extra laborers for a considerable length of time they organize another road gang; so that the work will be done by regular hands.

The reason of this needs no explanation. You know that laborers picked up for a few days will do *worse* work and *less* of it, than a regular employe and will require more careful watching while doing it.

The overseer has charge of a less length of roadway than his fellow workers, so that he may have time to inspect their work.

At one time, in a few of the departments, he was relieved from all manual labor, having nothing to do but see that the work of the others was properly done.

But this practice has been discontinued and to the improvement of the service.

The overseer's section is expected to be the best kept of his brigade, in fact serve as a model for them; to show that he holds his position by his superior ability, and NOT by virtue of the fact that he may be a friend of the engineer as might be the case, if he were a *walking inspector* only.

It has also been found beneficial to the service that the position of overseer be filled from the ranks of the laborers only—(civil service you see.)

The duties of the *overseer* require him to visit each member of his brigade once a week.

He makes a written detailed report of each of these trips, upon its completion, and sends it to the Conductor.

This report gives the date of the trip, the time and place at which each of his men was met, what he was doing, the manner in which he had executed the orders given on the preceding trip, and instructions for the direction of his work for the next one.

Thus once each week the Conductor has information showing him the status of the work at every point of his division.

The road laborer is upon the road from 5 a. m. to 7 p. m. in summer and from sunrise to sunset in winter. They wear upon their hats a badge which distinguishes them from other workmen.

They have also a numbered disc or signal fastened to a staff. This must be planted within one hundred yards of the point at which they are working.

Not only are they *not* permitted to quit the roads during bad weather, but they are expected to be more than ever vigilant, though permitted to construct shelter along the road, or carry a portable one for protection during the greatest violence of storms.

In case any traveler meets with an accident they must assist him gratuitously.

*Tools:**—Part of their tools they furnish themselves, part are furnished by the Government. All must be kept in good condition.

Duties:—1. Keep gutters clear so that water runs freely.

2. Scrape off the mud in wet weather and sweep off dust in dry so that the road is always clean.

3. To clean off the snow as far as possible, break up ice on the road and in the gutters during the winter.

4. Pick up all loose stones, break them, and pile them in regularly shaped piles on the side of the road ready for use in repairing the ruts and holes.

5. Keep mile posts in good order.

6. Take care of the trees bordering the road.

They are furnished with a register destined to receive the observations of any of their superiors.

In this register the agents note their names, time and place of meeting, nature of work upon which the laborer is engaged, and the orders and instructions given him.

This book when examined by the chief engineer, permits him to judge of the diligence and ability of his assistants, since they cannot properly fill the register without being conversant with the work, and at the same time permits him to judge the laborers themselves.

In addition to this they are supplied with blanks, and send in each month a report, giving for each day the nature of the work done, and the time required to do it.

The conductor makes a resume of these and sends it to the chief.

The zeal of the workmen is maintained by a system of rewards and fines.

A half day's wages is deducted if he is not able to present his register when demanded.

If not found at his post he is liable to a fine of two day's wages the first time, of three day's wages the second time and to dismissal the third time.

If he has not performed the work he should have done he is fined an amount equal to that which it would require to perform the work.

All or a part of these fines are distributed among those of the workmen who have distinguished themselves by their zeal during that month.

At the end of each year the laborer and overseer with the best record each receive as a present an amount equal to a month's salary.

The laborers are divided into three classes, overseers into two classes, equal numbers in each class. The division is made upon basis of

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*His tools are—wheelbarrow, iron shovel, wooden shovel, pick, iron scraper, wooden scraper, broom, iron rake, crowbar, hammer and tape line.

the preceding year's record. Time of service does not count. Indeed an old employe may descend in class, (but this seldom occurs.) They receive from \$10 to \$20 per month, according to the cost of living in that department, and the class to which they belong. Overseers receive a salary 20 per cent. greater *i. e.*, \$12 and \$24 per month.

Although, as you see, not remunerated by a princely salary, the position of road laborer is much sought by the peasantry, on account of the honor and importance attached to a government office, so that applications for positions exceed the needs and it has become necessary to make applicants fulfill certain requirements.

Thus aspirants for positions are compelled to fulfill the following conditions before being eligible to appointment by the Prefect of the Department:

1st. Age, 21 to 40 years.

2nd. No deformity preventing daily labor.

3rd. Must have had experience either upon roads or in construction *i. e.*, building.

4th. Must have a certificate of morality.

5th. Be able to read and write.

They may be discharged by the Prefect upon recommendation of the Engineer in Chief.

This system, while employed throughout France for the maintenance of the national roads, is applied to all the other roads in but 27 of the 87 departments.

In three departments, the Engineer in Chief has, it is true, the direction of the work, but has under him a different corps of engineers or commissioners to superintend the work upon the county roads.

In 57 of the departments a commissioner appointed by the Minister of the Interior, has charge of the county roads. His corps comprises commissioners or trustees in the arrondissements and cantons who are appointed by the Prefect of the Department.

In the old feudal days, previous to the French Revolution, the roads (except royal ones) were the property of the nobles through whose domain they ran.

The nobles were charged with the repair of these roads and of such bridges as might be upon their estates.

In order to enable them to do this, they were authorized to collect toll at certain places, which they were empowered to establish.

In case the toll collected did not suffice for the needs, they were given power to compel the peasantry to devote, *without charge*, the amount of labor necessary to keep the roads and bridges in good condition. This was in addition to the amount of time that they were required to work on the royal roads.

History does not mention that the French nobility was troubled

with anything resembling conscientious scruples. In fact that great uprising of the peopie known as the French Revolution, would convey the idea that they were more than usually unscrupulous.

As they were accountable to no one for the amount of tolls that they did collect, the custom came into general practice of turning all tolls into their individual pockets and turning the peasants out upon the roads for a longer period of time to work for nothing. At the same time they increased unlawfully the number of toll gates from 2,000 to about 5,600, as was found by an examination just previous to the Revolution.

The Kings sent billet-doux from time to time to their nobles reminding them that money collected must *not* be used other than for the maintenance of the bridges and roads.

But these royal proclamations had little or no effect, for the nobility was a great power at that time. The peasant could get no judgments against them for they were, by right of birth, the judges or magistrates themselves, and disposed of all cases to their own best advantage.

Among the acts of the new government following the Revolution was one repealing all acts authorizing forced labor upon any roads.

From that time on the peasantry had an easy time in so far as working to maintain the roads went; but when he came to use the roads in bad weather, he probably did not have as easy going as before. For although the communes were authorized to, and did, appropriate money for the roads it was all spent within the boundary of the villages. The roads in the open country were left to take care of themselves.

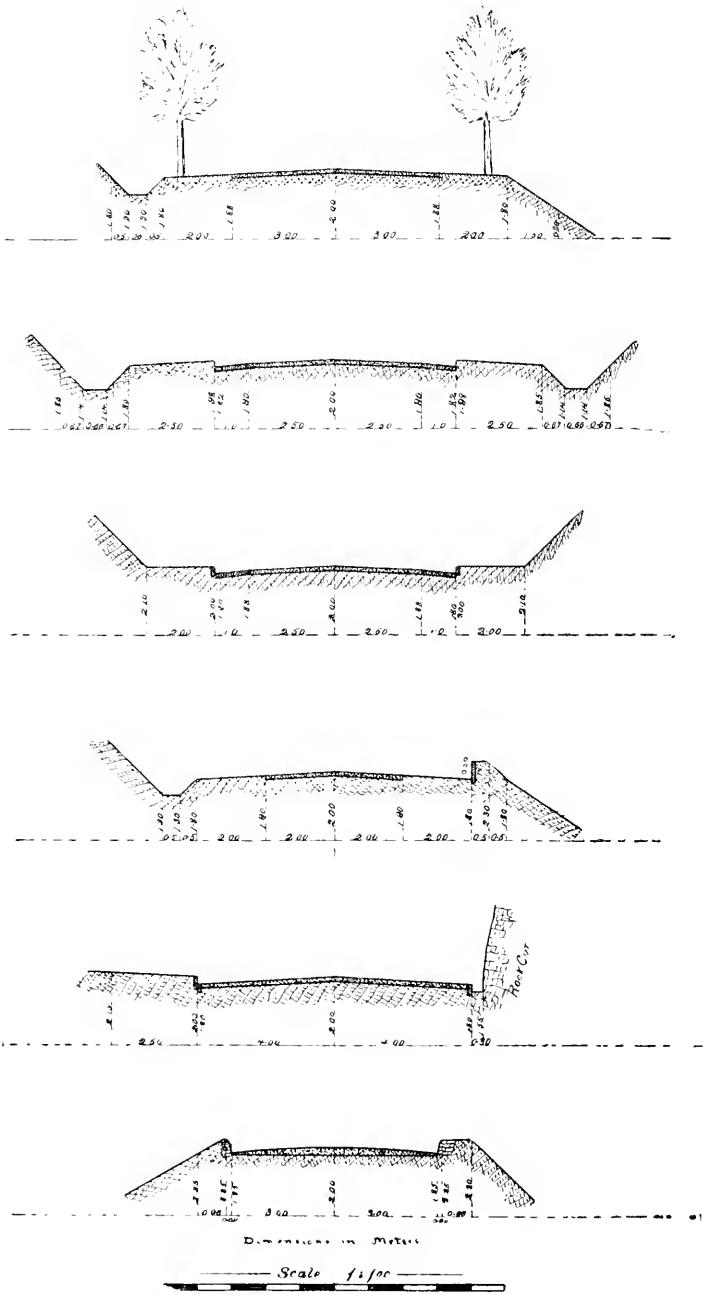
And so while the peasant put in his time indirectly upon the roads, he got but little benefit from it.

In 1824 this state of affairs resulted in a law, that in case the revenue of a commune was not sufficient to keep the roads in good repair two days of labor, and an additional special tax for the roads could be required. This may seem like going back to the old regimen but as a matter of fact it is under much different conditions; where *formerly* they were arbitrarily ordered out, to work, may be, in the farthermost part of the domain, with no option given as to time of working nor indemnity for loss of horses if they were hurt or died from exposure, *now* they are employed upon that part of the road which is near them, and the good condition of which is a matter of importance to them.

They have also the option of paying a money equivalent; at a certain rate per day, fixed for each of the departments.

Much of the repairing and construction is done by piece work and in case of a certain piece of work being assigned to anyone, they are al-

TYPES OF FRENCH ROADS



lowed a considerable length of time in which to do it. The number of days labor that may be required, has in subsequent laws been increased to four.

When money is paid a reduction of from 40 to 50 % is made upon the actual value of a day's labor in that department. But in spite of this fact 60 % of the people prefer to work out their tax.

This labor is directed and superintended, either by the Engineers of Bridges and Roads, or by commissioners appointed by the prefect of a department, as was previously explained.

The roads as constructed at the present time in France have in general the following points in common:

1st. A McAdam road bed 15-21 ft. wide, 6 inches thick, and having a crown of $^1/_{50}$.

2nd. A pathway upon either side, having a width of from $5\frac{1}{2}'$ to $7\frac{1}{2}'$, generally elevated about 5″ or 6″ above the gutter, in which case the gutters for the width of three feet are paved with paving stone.

In case the pathways are *not* raised above the roadway there are no gutters but the water drains across the paths into the ditches upon either side.

The ditches upon either side have usually a depth of $1\frac{1}{2}$ ft. and the same in width.

In case the road has quite a grade the ditches are arranged in cascades. When the road is upon a high fill there is always placed upon either side the small safety bank, $1\frac{1}{2}$ ft. high.

In 1874 the average thickness of the coating of the National Roads did not exceed 4″ (10 cm). In three of them it did not exceed $3\frac{1}{4}''$ (8 cm).

Nevertheless these roads did excellent service and show that for strength these thicknesses are sufficient.

But it would be false to build a road just sufficiently thick to support the traffic; so that after a short use they would be so worn as to require renewing to keep them from breaking up. This together with the consideration of a possibility of not being able to work upon them though they might require it, as in time of war, for example, has led to the adoption of 6″ (15 cm) as the average depth.

In extreme cases however they have been made to a depth of 20″

In cuts, slopes are 45° in earth, $^1/_{10}$ in rock.

The absence of a foundation in McAdam roads, which was a great objection urged against them: as in consequence of its absence, they would require a constant maintenance, whereas in the case of the Telford road even if the metal was worn out traffic could still continue upon the foundation. This objection has been *the one* cause of the supremacy of McAdam over Telford roads.

The necessity of constant care necessitated the organization of a

system for continuous maintenance. And strange to say it was found more economical than to let Telford roads wear down to the foundation and then replace them. This is not taking into consideration the advantage of having continually a perfect road bed, instead of a worn out one for the greater part of the time.

McAdam insisted upon no foundation and perfectly clean broken stone. Nothing being added under the pretext of binding.

The French while constructing their roads without a foundation, as McAdam did, were the first ones to add a binder to fill in the interstices.

This was first advocated by Polonceau, who at first mixed a tender rock with the harder road metal destined to take the wear. Then by rolling the softer material was crushed, making a compact solid mass.

This system is essentially employed today, upon all roads, with the exception, that instead of using a tender material, which requires crushing, they save the cost of crushing by employing materials already powdered; and do not apply the binder until after the broken stone has been thoroughly compacted. This is the system known today as *macadamizing*. Though containing a binder which McAdam did not use.

Road metal, for the maintenance of the national roads is furnished by contract, contracts being let to furnish upon a small section of road all the material needed for a number of years.

The road is divided into quite small sections, which makes it possible for peasants and small land owners to take contracts, which will give employment to their teams at times when they would otherwise be idle, and at the same time clear their land of stones, if they happen to be of the right sort. Otherwise certain quarries in the vicinity are specified.

All the material which they furnish one year is placed on one side of the road, while that of the next year is placed upon the opposite side, thus avoiding confusion.

The material furnished must be piled in regularly formed piles, usually rectangular truncated pyramids with a base one and a half by two and a half metres, having a height of one half metre, the volume being called one cubic metre, though slightly in excess of that amount.

Repairing and renewing a road are not the same thing in all cases with the French. While all roads are subject to constant repairs, some are being constantly renewed, and others are only renewed in large sections, from time to time, as they wear too thin.

In the first method wherever a hole is to be repaired an excess of new material is used. By so doing the amount of wear of road is being constantly replenished, so that the road never wears out.

In the second method no more than enough material is added to bring up the level of the hole to that of the road, which thus gradually wears down below the minimum thickness required to carry the traffic, and then in sections of several hundred yards in length, the entire surface is covered with a thickness of new material, to bring the thickness up to the required amount.

This latter system gives better results as to the smoothness of the road, but the organization of the service is more difficult under it, requiring large quantities of material in a short time, and the care of a large force of laborers.

The total cost of construction and cost of maintenance of the roads in France has been as follows:—

	Cost of First Establishment, per mile.	Annual Cost of Maintenance and Inspection.
National Roads, . . .	$10,000	$230
Departmental Roads, . . .	6,500	160
County Roads, . . .	2,700	80

Total cost of first establishment, $1,300,000,000: annual cost of maintenance and inspection, $32,000,000.

In considering the comparatively high cost of the national roads you must take into consideration the fact that being largely constructen for strategetic purposes, they have traversed the roughest and most sparsely populated parts of the country, and that their widths are greater.

In considering the amount of traffic upon the national and department roads, M. Durant Clay says: "A saving of one quarter of one cent per mile in the cost of hauling each load would make a annual saving of $10,000,000.

The interest at 5 per cent. upon the original cost of these roads ($380,000,000), $19,000,000, together with the annual cost of maintenance, $9,000,000=$28,000,000, say $30,000,000. So that it would only have to result in an economy of hauling of $\frac{3}{4}$ of one cent per mile to make the great system of roads a paying investment.

When you consider that the cost of hauling upon dirt roads even in good condition amounts to about twice what it is upon a McAdam road in good condition, you can decide for yourself whether this system of roads is worth what it costs.

TREES.

As far back as the middle of the XVI century, trees were planted along the Royal roads. This practice has been more or less continuously followed since that time. During several periods it was stopped by those in authority, they being of the opinion that trees were more of a damage than a benefit. But now trees are planted along all roads

having a width greater than 10 meters (33′) at distance varying from 5 to 10 meters, in single rows upon the narrower roads, and in double rows upon the wider. Trees cost from 40 to 60 cents a piece. They are selected from nurseries and of species most liable to thrive in the soil and climate for which they are destined.

In resume we have squads of five or six men each, in charge of an experienced workman as overseer, constantly employed in repairing the roads and keeping them clean. The overseers reporting to assistant engineers, who are men with technical education, they reporting to engineers who in turn report to the chief engineer.

Three grades of educated engineers are over all the work. With a system of reports which enable the chief engineer to tell exactly the state of the work at any point.

All material inspected and accepted by a competent engineer.

How different from the system in this country, where the farmer when he gets a little spare time in the middle of the summer—after the roads have gotten hard and smooth, though not level, goes out with a plough and under the supervision of another farmer, he digs out the ditches and fills up the road with the soft earth. Making rough and heavy again the roads, which had been bad all spring, but were just getting good. And where as at Norwalk it is possible for those in authority to pay $19,000 per mile for a broken stone road, covered with a soil brought from a long distance by rail, and which, as my informant told me, would have been excellent for raising cabbage, but which upon the road made it far worse than it was before.

Of course he might have been a little prejudiced, as he had to pay a thousand dollars because the road ran near his farm.

DISCUSSION.

Mr. H. M. Claflen:—I regret that a previous and imperative engagement takes me out of the city Monday evening, and I must forego the pleasure of listening to and partaking in a discussion of the paper on "French Roads," by Prof. Neff.

There cannot be "Neff" said on this subject, and I am ready to sacrifice all the property of my wife's relations in "mending other people's ways" and let my own ways go.

One of the largest expenditures of a nation is in its streets and highways, and our dear and native land has expended more, and has less in proportion to show for it than any civilized country.

To learn lessons of wisdom from the experience of others in solving the previous question is not in the category of the American tax payer, and an "object lesson" introduced and paid for by themselves at

a usually fearful cost is the only school that teaches lessons that are remembered and from which wisdom is gathered.

I trust the Professor may find good soil in which he may plant seed that will bear fruit, for much is to be learned from the French methods of constructing roads, both to be adopted and to be avoided, but it seems to me the whole subject might be condensed in a few words like this, resolved, by the Civil Engineers' Club of Cleveland:

"That good engineering suggests and demands in the construction of street pavements, that no material shall be used that will not meet the demands of wear and tear made upon it for at least 20 years, and that the use of inappropriate material in construction of pavements, is on a par with the use of poor material in a bridge, a building or any mechanical device, and to ask of a material a duty it cannot perform is unprofessional."

Acting upon this platform, you would not see people petitioning the authorities to protect their pavements from legitimate traffic: permanence would take the place of the short lived, and the tax payer would secure for his money expended, very much larger returns, the air of respectability that well paved streets give to a city, is much the same when compared with bad work as that which comes from comparing the well dressed gentleman to the beggar in rags.

Mr. Gallup:—I would like to ask about the width of the tire on the wheels, are they different from ours?

Mr. Neff:—I do not think they differ so greatly. A large number are two-wheeled wagons with tires about five inches wide. In regard to macadamized roads they are used in the cities instead of stone pavements. If they use pavements in the cities repairs will not exceed 8 %.

Mr. Bowler:—I have been told that in the village of Collinwood they have filled the streets with slag and covered that over with clay. It does not seem to me that that would be very economical. I should think in wet weather the clay would slide off.

Mr. Lander:—I am somewhat interested in that road as I am one of the parties who had the repairing of the road, and was not aware any clay was put on the road.

Mr. Bowler:—Well of course I have not examined the road, and do not know anything about it from direct knowledge, but my informant was a resident of Collinwood. This question of roads is a question of education and needs to be agitated continually. The people must be educated up to the point of keeping the roads in good shape. They all want good roads but want some one else to pay for the repairs.

President Gobeille:—Some one has said the better the roads the less the religion among the people.

Mr. Bowler:—I do not believe that. I heard a man say, who

thought he was very wise, as he looked from the Viaduct down on the stacks at Detroit street: "What we want in this city is more chimneys and fewer churches."

WORLD'S FAIRS.

By Frederick E. Sickels, Member Engineers' Club of Kansas City.

[Read October 12, 1891.]

In attempting to make a suggestion in relation to the World's Fair to be held in Chicago, the writer prefers to preface it with some remarks founded upon recollections of previous fairs of the same general character.

A great feature of international exhibitions, historically considered, is the lasting effect which they produce, and in this connection it may be well to consider some of the lasting effects produced by the exhibitions which have been heretofore held.

Beginning with the exhibition of 1851 in London, then called the Crystal Palace. the lasting effect of this exhibition, it is not too much to say, can be found in the architecture of many civilized countries of the present day. The building was made of iron and glass, and was almost a revelation to many as it demonstrated the importance of light in exhibiting the various articles which it contained. True, a building made of iron and glass was old, as used for hot houses, but it was new as used for the purpose of exhibitions of this kind, and all exhibitions since have to a greater or less extent copied after that exhibition, and nearly all important buildings since erected have been modified to a certain extent: in that they have larger windows admitting more light than was customary prior to 1851. The architects of the world were taken to school, so to speak, as regards the value of light in buildings, and this schooling was of a peculiar character as all visitors to the Crystal Palace were at once convinced of the great value of light to assist them to properly see the different exhibits, and architects had to follow the popular cry for more light in buildings or loose their trade.

The antagonism between the requirements of Greek art and the admission of light into buildings is such that the struggle to obtain more light with less conformity to Greek art has been going on for several centuries, and a great impulse was given to the admission of more light by the example of the Crystal Palace in 1851.

Another noticeable, and perhaps historical, event of this Exhibition

may probably be best described by stating that the American exhibit within the building was very poor, and to partly compensate for this, a number of enterprising Americans went over to England in the yacht "America" to compete in the yacht-race for all nations, and the "America" was almost a wonder to the English as compared with their best sailing vessels. She outstripped them all so greatly that it was really no race, and she brought to America what has been called the "Queen's Cup." Since that day the English have made strenuous efforts to defeat the American yachts on this side and thus win back the cup. The last attempt was made by the "Thistle" against the Boston-built vessel "Volunteer" near New York harbor on the 27th of September, 1887, and the struggle which had been going on from 1851 until that time was apparently settled by the result of this race when it was conclusively proven, other things being equal, that a vessel without a center-board could not compete with a vessel provided with one. It would be difficult to say how much money was spent in determining this question on the occasion of the last race. Steam yachts came over from England to witness it, and an immense fleet of vessels was gathered to accompany the two yachts on trials, and when the "Volunteer" came up into the wind and shook out her jib-topsail before crossing the line behind the "Thistle," it was to be again determined whether the Americans or the British were masters in the art of building sailing vessels. In 1851 the Americans, in pleading their case in regard to their lack of interest in the exhibition, declared that the space which had been assigned to them had been reserved because they contemplated putting the yacht "America" into it so that the European nations might have a correct model of a sailing vessel. The "America" that won the cup in 1851 was a schooner-yacht without a center board. The difference between her model and the model of the English vessel at that day consisted mainly in sharper lines forward, with greater rake to her keel, and greater width aft, above and at the water line. In other words, her model wss superior in that it afforded bearing surface to keep from upsetting when under a heavy press of canvas, at the same time being easily propelled through the water. The result of the last contest proved the Americans to be yet ahead in the art of making fast sailing vessels, after forty years of trial. As steam has now superseded sail upon the ocean, trials of sailing vessels are not of such world-wide interest as they were in 1851 but the trial at that time made a new starting point for naval architects.

The other noticeable event which was creditable to the Americans was the exhibition of the American reaping machines, the McCormick and others. Although reaping machines were in use in the very early part of the century, as for instance, the Bell reaper, yet the exhibi-

tion of the reaping machine at that time spread the knowledge of its value over the civilized world, and may be regarded as one of the hirtorical events of that exhibition.

So that of the Exhibition of 1851, three historical events may be named: the building itself, the yacht "America," and the demonstration of the value of the reaping machine by public trial.

The Exhibition of 1853-54 in New York contained no historical feature, without the writer be permitted to suggest the first power steering-machine which was exhibited by him in operation at that exhibition. Since that time power steering machines have come into use throughout the nautical world. The building was much after the plan of that of 1851, but smaller. It was destroyed by fire. While it remained it demonstrated the beneficial effect of a large amount of light, and no doubt contributed to impress the lesson of the exhibition of 1851 in that respect. It was made mainly of iron and glass.

The Paris Exhibition of 1855, following so soon after those of New York and London, presented no novelty of historical interest.

The London Exhibition of 1862 can hardly be said to have contained anything of European origin which might to any considerable extent be termed historical. It had a large collection of the products and industries of all nations, with the exception of the United States which had not much standing in this exhibition because of the war then going on in America, and the few exhibits taken over there found place among those of the European nations. The writer had the original steam steering machine (exhibited in the Crystal Palace and in '53-54) on exhibition there, but it was given place in the apartment assigned to Belgium, and had only the American flag over it to indicate its nationality. It had between its first exhibition and this time been put into practical use, and on its second exhibition was shown as the first power steering machine made or used in the world, and no doubt its exhibition in London contributed to instruct the maritime nations of Europe to some extent in the value of the application of power to the rudders of vessels. The writer had to take the precaution of having it shown by an Englishman, as it was impracticable at that time for an American to remain with any of his exhibits without being constantly harrassed by insulting remarks made in regard to his country, as it was then the common belief in Europe that America was ruined and in the process of general disintegration and destruction, and some English visitors could not resist the temptation to taunt an American with the fact.

There was in the Exhibition of 1862 two steam engines from Germany. On them was the "trip cut off," patented by the writer on the 20th of May, 1842. The writer appeared in the catalogue and was known at this exhibition as the exhibitor of the first power steering

machine, and it was not known to the great number of visitors that he had anything to do with the "cut off" applied to the engines from Germany. He availed himself of the fact to make inquiries and learn the opinion of the various European engineers in regard to what was termed the "German cut-off." Attendants of the machine stated the "trip cut-off" to be a recent German invention. He found that exhibiting engineers and others regarded these German engines as having a "rattle-trap" for a "cut-off," and they had no hesitancy in expressing the opinion that this German invention was entirely worthless and wholly unsuited for steam engines.

Upon these machines the exhibitors had a card with the words "For Sale," and the writer was curious to know if they were sold in England at the close of the Exhibition. His recollection is that the card was still there at the close and that the engines were returned to Germany unsold, though as a matter of fact they were the best land steam engines in the exhibition. This incident demonstrated the power of a class of men to prevent the introduction of an improvement which might effect their interests, when the improvement, from the nature of the case, is of such a character as to baffle the judgment of the public as to its merits, and the writer could but reflect that the invention which was so unanimously condemned by European engineers had at that time been gradually coming into use in America for twenty years, and yet it was to a great extent unknown in Europe. And while it is now in use throughout the civilized world, yet for the first twenty years it was almost unknown outside of the United States. No doubt the exhibition of these German engines contributed to draw the attention of some engineers to a slight degree to the merits of this form of cut-off, but the writer was astonished to learn that the opinion of all European engineers, so far as he could gather, was decidedly unfavorable to it in 1862.

There were other exhibits, but none of such novel character as the first power steering machine. There was the ammonia ice-machine, substantially the same as now used. The Lenor gas-engine was there shown as it is now. The arc-light with the means of adjusting the electrodes by the strength of the current was also shown in full operation. The metallic-cartridge, breech-loading gun was there shown substantially in all its perfection of the present day, and a marvelous experience which the writer had at this exhibition was the training and drilling under intelligent officers of troops in the parks of London close to the exhibition, using the old-fashioned muzzle-loader and ramrod as though it was the best to be had, and all this at a time when England was endeavoring to equip her land troops with the means of greater military power in view of a threatened invasion by the French.

The writer at that time asked himself the question, if it took so

long to satisfy military authorities in regard to the utility of the breech-loader, how long would it take to satisfy the nautical world of the value of power as applied to the rudders of vessels? Experience has shown that it did not take so long from that time to do so as it did to introduce the breech-loader after its first use by the Prussians. It is within the writers knowledge that the Prussian needle-gun, a practical and efficient breech-loader, was then nearly twenty years old and had been in service in the Prussian army for nearly that length of time; yet European nations continued the use of the muzzle loader, changing ends of the gun twice, changing ends of the ram-rod twice, and taking off and putting on percussion caps in loading, the whole manipulation being unnecessary in view of the existence of the breech-loader. Power applied to the rudder of vessels came into use more rapidly after its first application than did the breech-loader. But there is an explanation of the difference of time required in their introduction which further illustrates the influence of a class of men to retard or promote the introduction of new and useful inventions. In the case of the breech-loader, its substitution for the muzzle-loader required a change in the training of troops. In the case of the power steering machine, the original machine was purposely constructed so as not to require the least difference in working the ordinary hand steering wheel. Any person qualified to steer a vessel by hand could work the same steering wheel with which he was acquainted in the same manner as he had been accustomed to work it without any additional instruction. Thus some of the prejudice against power steering machines was avoided.

No doubt the exhibition of the breech-loader in 1862 had a tendency to draw the minds of the military men to their great importance, and the exhibition of the arc-lamp, the ammonia ice-machine and the first power steering machine had some influence in furthering their more rapid introduction.

With the Paris Exposition of 1867 the writer is not familiar, but he has no recollection of that exhibition containing anything of historical character, although it had an immense collection of the products of all nations.

In the Exhibition of Vienna of 1873 perhaps the only exhibit of historical importance was the more advanced improvement in the generation of electricity by means of the dynamo.

In the Philadelphia Centennial of 1876 the telephone was shewn in operation. No doubt its exhibition at that time greatly tended to further its rapid introduction.

The most prominent feature of the Centennial to Europeans was probably the passenger traffic which was carried on by the locomotives in the midst of the people without sacrifice to lives. It illustrated to

the foreigners the character of the education of the great mass of American people who were expected to take care of themselves when surrounded by the dangers of railway traffic; in Europe the railway crossings at grade of streets would have to be provided with gates and guards for the security of the people. In the Centennial grounds a locomotive was running around, depending upon the watchfulness of the people to avoid accidents. Nothing more marked the peculiar features of American civilization to foreigners.

The Japanese exhibit in the Centennial of '76 contained specimens of art according to their rules of art which compared favorably with the finest specimens exhibited, and their ornamentation has since been copied throughout the United States to the extent that wood-work is now varnished instead of being painted, and in the resort which artists now have in copying some of the simpler forms of Nature in ornamentation. To the Japanese must be accorded the credit of educating the largest number of people in respect to art.

The Vienna bread made at this exhibition was a great educator to the people of this country, and the effect of this education can now be seen in the bread generally produced throughout the United States.

While the Paris Exhibition of 1889 contained an extensive collection of exhibits, the only historical event of note was the erection of the Eiffel tower which is, no doubt, an immense structure. But nothing particularly new or especially instructive was in this exhibition.

Whatever may be the result of the Chicago Exposition, it is certainly to be hoped by every American that it will contain some historical exhibit, no doubt it is much easier to suggest that it should contain such an exhibit than to say what it shall be. In view of the difficulty experienced in trying to change the habits of thought of a large class of people as illustrated by the foregoing examples, excepting in cases appealing directly to the people as illustrated by the marked educational effect impressed upon the masses by the Crystal Palace building of 1851, it is desirable in the historical exhibit of 1893 to have it of such a character as to directly appeal to the physical sense of the crowd of visitors, and to that end the writer would suggest a building provided with means of maintaining a uniform temperature during the whole of the Exposition. This building should also be provided with a means of excluding all dust so that every visitor who passed through it should at once notice during the warm and cold days that it was uniformly agreeable without regard to the atmospheric changes taking place on the outside, and they would also notice that the air was pure and without dust, and would realize that in the progress of the arts man had come to be able to regulate and maintain the temperature and purity of the atmosphere in buildings, and that it was only a matter of expense and time when this im-

provement would be found in buildings throughout the world.

To accomplish this result it is only necessary to have recourse to known methods of maintaining uniform temperature in buildings, and to make use of devices and appliances long since in use in passing the air through suitable screens to exclude the dust. If any such attempt is made at the Chicago Exposition it should be by men possessed of a full knowledge of the subject, and the building had better be small that it may be done thoroughly and kept within the amount which the directors of the exposition may deem advisable to expend.

This equable temperature building should be filled with exhibits calculated to draw a crowd of visitors, and thus the impression would be made upon a great number of people that it was practicable to maintain an even temperature and supply air free from dust within a building crowded with people. A recording instrument for the temperature should be within the building to show the uniform temperature while the outer air was changing from day to day.

It is only necessary in carrying out such a design to have the proper mechanical skill and knowledge to insure perfect success. All the different parts of the apparatus required to be used have only to be assembled from separate examples which have been in use for a quarter of a century, and bringing them together for the first time would, in itself, be a novel and interesting feature of the Exposition. The impression created upon the minds of the public by this example would be lasting, and the younger visitors would be able to say in future years that it was the first example of a system of warming, cooling and ventilating that had subsequently come into extensive use.

Plans used to accomplish the result obtained in this equable temperature building should be published with notice that all patents used had expired. An account of the whole result with cost of plant and cost of maintenance should be given with any suggestions as to faults and remedies discovered so as to as far as possible properly start the effort of controlling the character and temperature of the air in buildings. This is one way of making an historical exhibit.

As no private person would derive any special profit by such an effort as here suggested, it could only be fostered by the managers of the Exposition for the sake of having at least one novelty that all could see for the first time.

The writer will mention some details for carrying out the suggestion made in regard to the equable temperature building. The size of the building to be 30×120 feet, one story high, containing a central avenue 8 feet wide running from end to end, the visitors coming in at one end and going out the other. It should have an entrance vestibule 30 feet long and ten feet wide, the floor of which should be covered with iron matting so that the dirt on the shoes of the visitors

would be exposed to the action of the thin vertical web of the matting in moving over it. Through the floor a strong downward current of air should be maintained to carry away the dust and other deposits on the iron matting, so that as the visitors reached the main hall they would be divested of all loose dirt and dust upon their clothes. Turn-stile doors should be used of large dimensions to allow easy ingress and egress without permitting a current of air outwards. These doors could revolve in semi-circular enclosures as before practiced in fitting up storm doors. The air should pass in at the sides of the building and out through the floor, the floor to be laid with a slight opening between each plank. The openings all around the sides and ends of the building for the admission of air should be about eleven feet above the floor. Openings in the roof should also be provided to permit some of the air to escape in that direction. The sash should be tightly fitted, the object being to maintain within the building a very slight outward pressure of air. The incoming air should flow through properly prepared cloth gradually winding and unwinding upon rollers so as to present a fresh surface of cloth while the other portion was being cleaned. For heating the air it could be passed over heating surfaces, and for cooling, over cooling surfaces which could be either refrigerating pipes or ice. Thermometers should be placed in different parts of the building and attendants at hand to watch and regulate the supply of air at different points as indicated by the slight changes of the thermometer.

As this building would be quite an attraction for visitors on unpleasant days, it would be necessary to have only one main avenue so that visitors would be obliged to pass out without unnecessary delay to admit others.

The secret of success in carrying out this plan would be in making ample provisions for the most extreme weather that would occur during the Exposition so that an uninterrupted success would follow. It is better to have a surplus in a first trial like this than a slight deficiency, and in the future use of the same idea no doubt much less expense would be necessary because it would be no longer a question as to whether it could be done if complete success attended its first trial. But if it fail, however slight the degree, that slight failure would tend to create a doubt as to the possibility of complete success and retard the introduction.

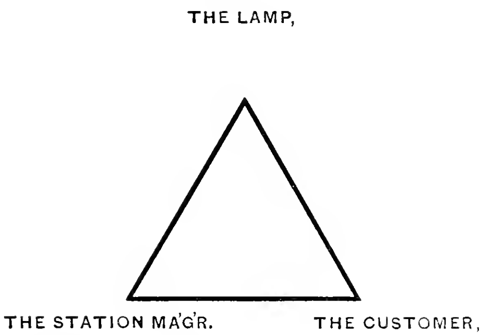
After such an exhibition as here suggested, by which the merits of maintaining a uniform temperature of pure air in buildings would be brought to the attention of a large number of people, it may reasonably be expected that further improvements in the same line would be introduced. It may be found desirable to vary the temperature in buildings as the barometer, thermometer or hydrometer varies in the

open air. It may be found desirable to charge the purified air with the odor of flowers. As the presence of ozone in excess has been supposed to indicate a healthy atmosphere, the air may be charged with this form of oxygen. As the changes in the barometer effect invalids suffering from asthma, rheumatism and other diseases, it may be found desirable to control the pressure as well as the temperature in hospitals. Many other additions and modifications of the general id e after its exhibition would no doubt occur to the crowd of visitors examining the first trial of an equable temperature building.

"THE LAMP," THE "ELECTRIC LIGHT STATION MANAGER," AND THE "CUSTOMER."

By E. P. Roberts, Member Civil Engineers' Club of Cleveland.

[Read October 13, 1891.]



It will be noticed that my paper is headed with a triangle having "The Lamp" at the apex and at the lower angles, "The Electric Light Station Manager" and "The Customer." The latter term being used to signify the person who pays for the light, whether he pays for the lamp directly or indirectly.

I had at first thought of heading the paper with a figure of a lamp, and from it radiating three lines—marked as shown in Fig. 1. It has, possibly, a more artistic effect than the device chosen but, as I looked at it, the idea presented itself that it was symbolical of three forces pulling in different directions, and that such was too much the actual fact. Therefore I chose a figure which symbolizes a closed circuit of strains and stresses. It indicates that the three factors are mutually dependent, and none can exist without the presence of the others. Such being the case, it is certainly wisdom that they should be well

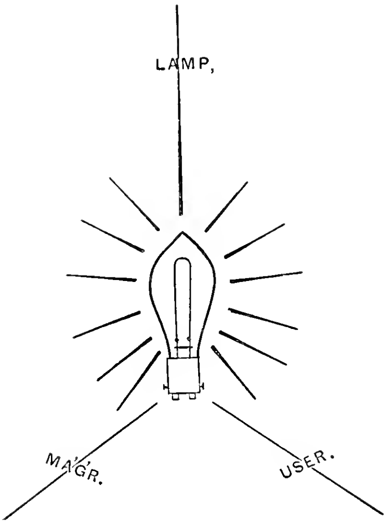


FIG. 1.

acquainted with each other's peculiarities, and it is not sensible to endeavor to hide anything because it is short of perfection. If it be attempted, the fall from an unwarranted elevation may bring utter ruin, whereas, if the failings are accepted, because of the great benefits otherwise unobtainable, there is no fall, as the article is already on the proper level.

First—We will enquire as to what is desired by each of the three factors.

Second—We will investigate as to how nearly the desires can be satisfied.

As any one who studies mechanism is sure—if he really be a mechanician—to give the product of his brain a personality, we will speak of the lamp as though it had desires of its own which, when allowed to govern, enable it to do it's life work as intended by its creator but, when over-ruled, disaster follows. This being the case, "The Lamp" desires to be understood.

"The Customer" wants a lamp which will consume little energy, (provided the energy is metered, as eventually it always will be); will maintain its original candle power at constant voltage during its life; and will have a long life. If he pay for lamp renewals he wants a cheap lamp.

The Electric Light Station Manager wants a lamp which will have the characteristics above mentioned, and which will never be broken, either in transit to the Electric Light Co. or in transit from the same to the customer; all, apparently, a matter of "transit" to some managers, when making claims against the lamp, whether it be carried in a lineman's pocket or otherwise; also that will stand screwing into a socket by means of a pipe tongs.

To what extent does the lamp of the present day fulfill the above modest desires?

It is not necessary to tell you what a glorious thing an incandescent electric lamp is, nor is it advisable to go into its history; as to the first, its advantages are well understood; as to the second, recent patent litigation has furnished a mass from which any one can take his choice, or can therefrom deduce a new history of his own.

Therefore taking it as granted that the superiority of the incandescent electric lamp over all other methods of artificial illumination of interiors is well understood, we will examine the lamp in detail to the extent necessary to furnish the character of information desired by intelligent customers. How a lamp is made he cares not, provided the results are good.

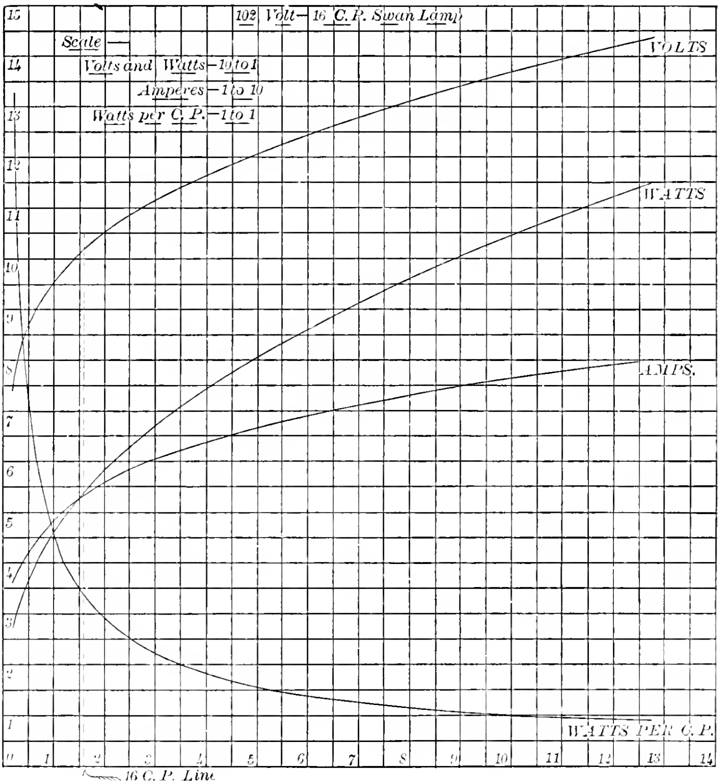


PLATE I.

At the present time lamps are made with much higher initial efficiency, average efficiency and life, than those made a few years ago. The price is also one-half, or less. The mechanical finish and general proportions are usually excellent, and the breakage in transit small. With reference to the last item, it is a curious fact that the shippers of bulbs to the lamp manufacturers, in common with all glass makers, state to the lamp company superintendent that he must expect a breakage of 5 % in transit, and that anything less is fortunate. For anything more they blame the railway company. On the other hand,

the customer of the finished lamp expects, or rather claims as a right, "no breakage" and also objects to weight of package. To the man *in between* it seems, let us say, curious. Even with all the improvements, lamps are not yet perfect. They still consume energy—they will give out in time—they will not maintain their candle power at original voltage during life—and they can be broken by very rough handling.

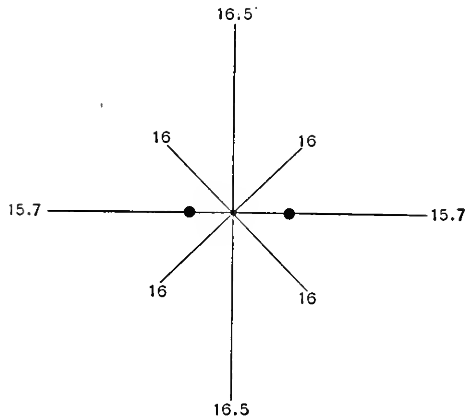


FIG. 2.

First—With reference to the candle power of a lamp. Evidently it is not the same at all angles, but for commercial comparison it is, in most cases, quite sufficient to take the mean horizontal candle power. This is obtained by measuring the C. P. around the horizon and taking the mean. For the lamp plotted in Plate 1 the relation of C. P. to position is as shown in Fig. 2, the point at which it gave 16 C. P. being 45°, and the C. P. at 0° and 90°, being as shown, and the plane of the filament being indicated by the small black circles. The voltage necessary to give 16 C. P. at other points is shown in Fig. 3.

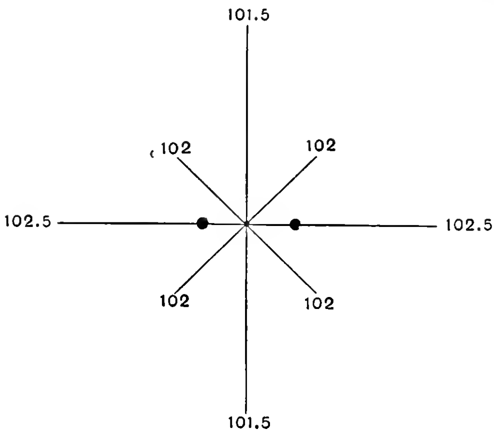


FIG. 3.

Curve "a" of plate 1 shows the relation of P. P. to voltage for a 102 V. 16 C. P. lamp, and curves "b" and "c" the relation of C. P. and watts to voltage, and therefore C. P. for the same lamp. Plate II "a", "b" and "c" are similar curves for a 51 V. 16 C. P. lamp. (At this point the lecturer operated a 50 V. 16 C. P. lamp at the various voltages shown in the curve, stating the C. P. corresponding

thereto. At 92 volts and 320 C. P. it ran for over half an hour without blackening. The lecturer, however, stated that such remarkable results could not be guaranteed.) Evidently a lamp can be made

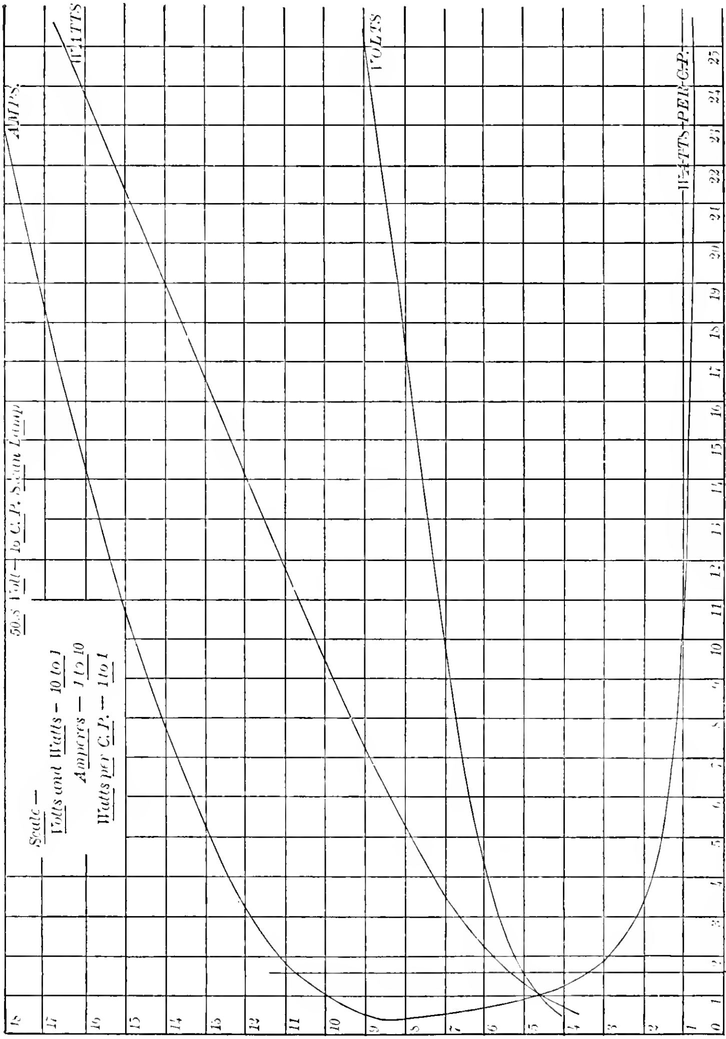


PLATE II.

which will not consume much energy per C. P. Why are not the best results above shown, obtained in practice? Because the life is shortened.

Plate III shows the effect of various voltages upon the life of a 100

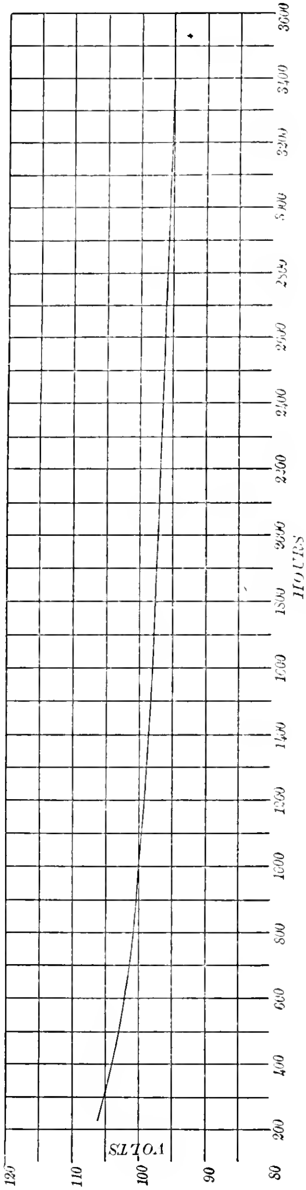


Plate III.

V. 16 C. P. lamp. This curve is plotted from figures given in a pamphlet issued by the Edison Co. According to the curve, a lamp lasting 1,000 hours at 100 volts will last a greater or less time at other voltages to the extent indicated. It is the result claimed to have been obtained by burning many hundreds of lamps in the laboratory, with the greatest care to keep the conditions constant. The tests were made some time ago, and lamps have improved since then—on the other hand, lamps are now operated at a higher initial efficiency than formerly, and therefore the results are probably not far from being correct. Accepting such as a fact, and I am sure that the importance of maintaining a constant voltage—if life is desired—will make itself very evident by a study of the curve. A lamp at 100 V., which would last one thousand hours, if at 102 V. will last only 600 hours and at 106 V. only 233 hours. Regulation within 3 % at all times is much better than the average.

Plate IV gives the comparative life of lamps designed to operate at different initial efficiencies. This curve Plate IV is taken from a paper entitled "Maximum Efficiency of Incandescent Lamps" by John W. Howell and read April 14th 1888, before the American Institute of Electrical Engineers. Mr. Howell is well known as an authority on the Incandescent Electric Lamp and, in the above article, he shows that the maximum economy in station operation is reached when the lamp costs 15 % of the operating expenses. According to his figures when the lamp bill is more, less efficient lamps should be used; when less, a more efficient lamp, having

shorter life, will give the minimum total cost of operation. Of course when customers buy their own lamps, the more efficient the lamp the better for the produce for current; evidently so if on a "per lamp" contract basis and just as truly so if on a meter basis.

The next point to consider is the average efficiency of the lamp, in other words, "How much does the lamp drop off when in use?"

Mr. Wm. H. Peirce read a paper before the American Society of Electrical Engineers, June 8, 1889, upon this subject. From his experi-

Curve showing lives of equally good lamps, burned at different efficiencies.

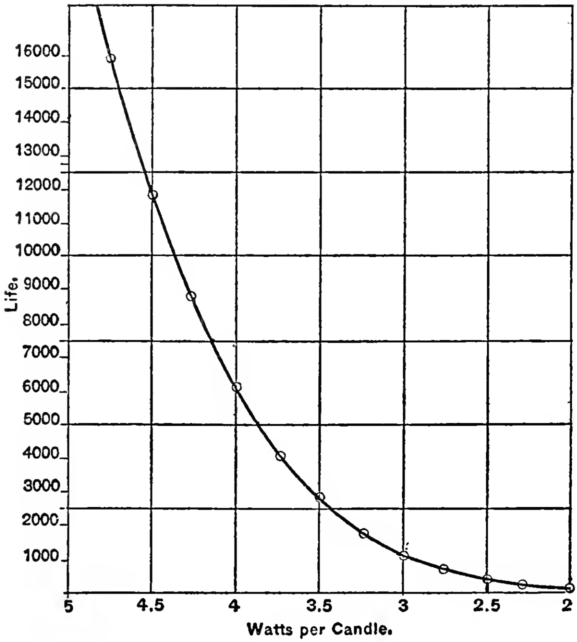


PLATE IV.

ments, which were unfortunately with too few lamps to be more than indicative, he concluded that the lamps which he obtained showed very considerably higher *average* efficiency when made of low *initial* efficiency. In other words, that the average "C. P." per watt of the lamp with *low* was greater than for lamps of *high* initial efficiency. Lamps have improved since his tests were made but the general fact remains as then. However there is a demand, and it is a legitimate one, for lamps of higher initial efficiency than 4 Watts per C. P.; which has been a very common actual initial efficiency for all C. P. lamps in recent times; and lamps are now made of from 3.1 to 3.75 Watts per C.

P. for 16 C. P. lamps. Which limit it is advisable to approach, the lamps in either case being equally well made, depends upon the cost of power and the cost of the lamp. As the price of the lamp drops it is, evidently, economy to use a more efficient lamp even at the expense of life, provided it is not carried to such an extent as to make renewals an annoyance although theoretically the greatest economy is thereby obtained. Practical considerations must not be lost sight of when following deductions from theory, or from the Ledger, or deductions from the receipts will result.

A table was then shown giving the results obtained by operating some experimental 16 C. P. lamps at the voltage at which they originally gave 32 C. P. The drop in C. P. at the original voltage and the increase of voltage necessary to give the original C. P. was shown, and the increase of "R" was noted. Also the fact that with lamps of the same initial efficiency the shortest life lamp would sometimes have a higher C. P. after 250 hours of life then one which gave out at possibly 500 or 1,000 hours. The figures were from experimental lamps under abnormal strain (16 C. P. operating it 32 C. P. and were not submitted for publication.)

The term "efficiency" has been used in the preceding paragraphs in its usual signification in lamp work, that is as expressing the relation between energy furnished the lamp and the amount of light emitted which would appear to be equivalent to a certain number of standard candles when measured in the ordinary forms of photometer. The real efficiency of a source of light is the relation between the energy consumed by the lamp and that given out as light. The last factor is determined by measuring the energy given out as heat, the difference between such amount and the total energy furnished is light and amounts to from 3 % to 7 % according to the degree of incandescence. This portion of the study of the lamps is very interesting but it is aside from the topic of this evening. Prof. E. L Nichols has done much to help the Electrical Engineer in this line, as in others, and most of his work has appeared in the Transactions of the American Institute of Electrical Engineers, and in the technical papers of even date. His paper on "The Efficiency of Methods of Artificial Illumination," March 12, 1889, is especially valuable in this consideration.

It has now been shown that an Incandescent Lamp has some properties the study of which may well tax the brain of a manufacturer. No engineer will wonder at this when he recollects that the principal element in an Incandescent Electric Lamp is carbon. The mere mention of carbon brings to mind materials of varied character wherein carbon is either the controlling element: as in soft iron, hard steel; or wherein carbon by itself exhibits most surprisingly different

characteristics. The study of carbon is a life-long study worthy of men of the greatest intellect and the incandescent lamp manufacturer has an opportunity to become acquainted with the element in some very trying moods, sometimes it is only a speaking acquaintanceship, sometimes it is not even that, the peculiar phase hinted at is so elusive. At other times *speaking* hardly "fills the bill."

In addition to the qualities above mentioned the carbon must be strong to withstand the jars of shipment. The glass must be clear and tough and must not crack, and the cap must not work loose.

One point has been left to the last. It is *cost.* It is getting to be more and more the custom for the user of the energy to supply his own lamps, the electric light station merely furnishing energy and charging by meter. This is as it should be. The cost may be considered either as the cost per lamp of the standard desired, usually 16 C. P., or may be taken as the cost per C. P. Higher candle power not costing proportionately more for lamps and, up to 50 C. P., usually no more for fittings. Of course extra for wire and fuse fittings of greater capacity. In any case the cheaper the lamp the better for the consumer and for the station manager. The less the total outlay for the purpose of obtaining light the more freely it will be used. The electric light station manager should do the same as the gas company does, bring the supply to the premises of the consumer, install, after being protected by a deposit, a meter, then furnish current and do nothing more. Everyone, except the stockholders, considers a corporation furnishing light as a band of robbers, and, for the company's sake, the less it has to do with wiring, furnishing lamps, etc., beyond inspection, the better. The day when such a course is generally practicable has not arrived but is, I believe, coming.

A resume is as follows:—

The lamp should be	Efficient. Long Lived. Cheap. Strong. Mechanically Perfect.	The inter-relations of these factors being dependent upon cost of power.

The Electric Light Station Manager should	know what he wants. get what he needs. use it as designed.

The Customer should	Understand that a lamp will not last forever or hold up its candle power any more than a gas burner will. Therefore take breakage and deterioration of lamp as an evil incident to, although overshadowed by, the great attendant benefits.

Appendix. As it is often desirable to know how much "*R*" to insert in series with an incandescent lamp in order to bring it to a

desired C. P. it may be of assistance to show how to calculate such amount.

By looking at Plate I and II the voltage for any C. P. for a 50 or 100 volt, 16 C. P. lamp can be obtained and also the current taken. Then insert the data in the formula for Ohms law: $R=\frac{B}{C}$ and the R is obtained and by referring to tables of carrying capacity the proper size of wire is chosen,

For example—A bank of 20, 100 V. 16 C. P. lamps to be reduced to 6 C. P. each.

Voltage for 6 C. P.=87.

Loss = 13 Volts.

"C" for 6 C. P., 49×20=9.8 Amperes.

Therefore "R"=$^{13}/_{9.8}$=1.3 Ohms.

Using* { Iron wire, wood frames=.092 Mills D., and 119′ long.
Iron wire, iron frames=.080 Milis D., and 90′ long.
German silver =.102, and 80′ long. }

After the paper an exhibition of special lamps of from 4 to 100 C. P. and focussing lamps was made. A little experiment which excited considerable amusement and interest was showing how to blow out an "Incandescent Lamp."

A small fan motor was run in series with a lamp and the lamp placed opposite the fan and the motor short circuited, the lamp burning brightly, upon throwing in the motor the lamp was cut down to an almost invisible red.

DISCUSSION.

Mr. Wason:—I would like to ask what success you have had in lighting street cars.

Mr. Roberts:—We have had success with all progressive lines. We have not yet lighted the East Cleveland lines (laughter.) The lamp for street railway work has a tied filament in it, as shown in this lamp (pointing to a lamp on sample rack.) This is a lamp of 50 c. p. for lantern purposes.

Mr. Barber:—There is one curve which Mr. Roberts has not shown, which I would like to see, i. e., taking a c. p. lamp on a constant potential current, and constructing a curve showing the changes in the c. p. during life. I would like to know the shape of such a curve.

Mr. Roberts:—The figures given and curves platted referring to this point, show changes due to abnormal strains. This is a 16 c. p. lamp at 32 c. p. It is not advisable to show actual figures because agents of lamps other than this one would advertise that their lamps

*Herrick, *Electrical World*, April 5, 1890.

did not do "so and so." Agents are very unscrupulous in such matters.

This matter has lately been well exemplified by one company which quotes a statement of an electrician of another company right in the line of the answer to the above. Often curves of this kind drop suddenly and then maintain a nearly horizontal line until it breaks. Others have the first drop given before shipment. Some drop gradually, and continue to drop until they manage to get such a high resistance, that a long, and generally unhonored, old age results. The ideal should be a horizontal line during life, be it long or short, and we are coming nearer and nearer to it.

Mr. Barber:—There is another curve that might be made, showing the number of watts taken on a constant potential current, until the lamp dies.

Mr. Roberts:—The figures I have given show an increase of resistance up to about 10 %. Mr. Pierce in his paper shows an average c. p. during life of about 75 %, lamps have improved since that time.

Mr. Barber:—I see that some manufacturers claim that their lamps do not blacken. I would like to know if there is a difference in lamps of different makes as to blackening. Can a lamp be made that will not blacken?

Mr. Roberts:—That depends largely upon the material from which the carbon is made, and its treatment before and after reaching the pump. We, in common with all manufacturers probably, can show lamps which burned two or three thousand hours, and without serious blackening. Sometimes remarkable results are obtained and the average is daily increasing.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

ENGINEERS' CLUB OF ST. LOUIS.

354TH MEETING. NOVEMBER 18, 1891. The club met at 8 p. m. at the club rooms, President Burnet in the chair and thirty-five members and two visitors present. The minutes of the 353d meeting were read and approved.

The executive committee reported the doings of its 118th meeting.

Col. Meier presentəd a letter from the treasurer of the General Committee of Engineering Societies the Columbian Exposition, which was referred to the executive committee.

Mr. Lawrence P. Butler was elected a member of the club.

A committee was appointed, consisting of all the ex-presidents who were present, to nominate officers for 1892. The names were as follows: Prof. C. M. Woodward, R. E. McMath, M. L. Holman, Col. E. D. Meier, Prof. F. E. Nipher.

President Burnet opened the discussion on the subject set for the evening—"The New Boulevard System of St. Louis." Mr. Burnet explained the law under which the boulevards were to be opened and maintained. The principal difference between a boulevard and an ordinary street came from the restrictions in regard to heavy traffic, stores and the building line. The expense of the care of the boulevards was to be borne by the adjacent property. The opposition so far came principally from the property owners who were not on the proposed boulevards. Mr. Burnet had prepared a large city map to illustrate the system, the streets to be used being marked with black worsted. About seventy miles were so marked, but it was doubtful how much would be used.

Full discussion followed by Messrs. Woodward, McMath, Flad, Wheeler Moore, Meier, Johnson, Bouton, Ferguson, Ockerson, Adams, Holman, Brauer, Russell, Macklind, Chaphe and Crosby.

Adjourned. ARTHUR THACHER, Secretary.

356TH MEETING, DECEMBER 16, 1891:—The Club met at 8 p. m. at the club rooms, President Burnet in the chair and thirty-six members and three visitors present. The minutes of the 355th meeting were read and approved.

The executive committee reported the doings of their 120th meeting, and announced the result of the ballot for officers for 1892:

President—J. B. Johnson.

Vice-president—B. L. Crosby.

Secretary—Arthur Thacher.

Treasurer—Chas. W. Melcher.

Librarian—R. E. McMath.

Directors—George Burnet and B. H. Colby.

Board of Managers Association of Engineering Societies—J. B. Johnson and J. A. Laird.

President Burnet called on Mr. Russell and Mr. Bryan to escort the newly-elected president to the chair. President Johnson, after a few remarks, called on the retiring president for an address. Mr. Burnet then read a short paper on the subject of "Roads." This paper pointed out the necessity of improving the roads of the country, and suggested the best means for securing such a result. Mr. Burnet requested that the paper be freely discussed by the club, and on the suggestion of the president the subject was made a special order for discussion at the next meeting, January 6th.

Mr. Frank S. Mitchell was proposed for membership.

On motion the secretary was instructed to announce that at the next meeting the question of a change from Wednesday as the day for holding the regular meetings would be brought up for discussion and action.

Prof. Woods then read the paper of the evening, on "Some Graphical Illustrations of the Relation Between Speed and the Weight of Reciprocating Parts in Steam Engines, Particularly in Locomotives." A number of diagrams were shown, illustrating their relation and the effect of varying speeds. An interesting discussion followed in regard to the design of the present side-bar and other parts of the locomotive, participated in by Messrs. Hermann, Bryan, Woods, Johnson, McNulty, Crosby and Farnham. Adjourned. ARTHUR THACHER, Secretary.

357TH MEETING. JANUARY 6, 1892. The club met at 8 p. m. at the club rooms, President Johnson in the chair and twenty six members and one visitor present. The minutes of the 356th meeting were read and approved. The executive committee reported the doings of their 122d meeting.

Mr. Frank S. Mitchell was elected a member of the club.

Mr. F. W. Raeder and Mr. J. P. Sneddon were proposed for membership.

The by-laws were amended as follows: Sec. 2, the sentence following the words "six dollars" was taken out and the following substituted, "Members elected during the year shall be assessed by the executive committee a proportional part of the dues for that year. In Sec. 7 the word "annual" in the last two sentences was dropped.

The following motion was adopted: "Resolved, that a vote of the club be taken on choice of night of meeting by sending a slip to each member on which he can state what night is his choice for meeting and also what night or nights he cannot attend."

Mr. Burnet opened the discussion of the evening on Roads and Road Laws, Messrs. McMath, Pitzman, Farnham, Meier, Moore and Johnson following with interesting and valuable suggestions on the subject. There was no question as to the importance of the subject and the desirability of trying to improve the present condition of affairs. The only point was as to the manner of securing the best results and what laws could be passed. The following committee was appointed to consider the question and report to the club: George Burnet, Julius Pitzman, R. E. McMath, Robert Moore, M. L. Holman.

Col. Meier reported that the Eads Monument Committee had made good progress and had been very successful in obtaining subscriptions in this country and Europe, and that they were now ready to push the work for local subscriptions.

For the next meeting, January 20, the following paper was announced: "An Inclined Cable Railway for Transferring Freight Cars between the Upper and Lower Yards of the Western Cable Railway Company," by Edward Flad.

Adjourned. ARTHUR THACHER, Secretary.

MONTANA SOCIETY OF CIVIL ENGINEERS.

DECEMBER 19, 1891:—The monthly meeting was held at 8 P. M. at the office of Messrs. Sizer & Keerl. Mr. W. A. Haven in the chair.

The following members were present: McRae, Farmer, F. J. Smith, Sizer, Foss, Herron and Keerl.

Minutes of previous meeting read and approved.

Mr. W. A. Haven, chairman of committee on State Engineer made a progress report.

On motion, carried, the chair named Messrs. McRae, Farmer, and F. J. Smith, as the committee to nominate officers for the ensuing year.

Discussion was had upon the features which should enter into the next annual meeting. On motion, carried, the following Committee of Arrangements for the annual meeting was named by the chair, and directed to perfect and carry out a programme without making a preliminary report: Messrs. Herron, Wilson, Keerl, Sizer and Rolfe.

Communications from the General Committee of Engineering Societies, Columbian Exposition, were read and the question of making an assessment to meet the amount charged this Society, was discussed and finally referred to the annual meeting for action.

The resignations of Asher Dole and Wm. Danforth, Jr., were accepted.

The Secretary was authorized to draw an order returning to the Executor of Franklin E. Worcester, the initiation fee paid by Mr. Worcester shortly before his death.

A communication from Mr. Benezette Williams, Chairman, Board of Managers, Association of Engineering Societies, was read, relative to the application for membership in the Association, made by the Scandinavian Engineering Society of Chicago. The question was discussed and finally referred to a committee of inquiry, with instructions to report to the Society's member of the Board of Managers, Mr. Keerl.

The death of Robert J. Walker, a member of the Society was announced, and on motion, carried, Messrs. Reeder and McRae were appointed a committee to draft suitable resolutions and to forward the same to the relatives of the deceased.

A circular letter of Dec. 12, 1891, was read from Senator T. C. Power, setting forth the features of an endeavor which he is making, looking to securing better and more comprehensive surveys of the public lands and such as will also embody elevations giving fuller and more accurate topography than that heretofore secured. The writer requested the Society's endorsement of the measure.

Following a discussion of the subject, the general plan proposed by Senator Power was endorsed, and the Secretary instructed to assure him of the Society's assistance in furthering the cause.

A committee consisting of Messrs. Foss, Keerl, and Smith, was appointed to take up the study of the question in detail, and to report to the annual meeting.

The Secretary was directed to notify the Surveyor General for Montana, of the Society's action upon Senator Power's communication.

Mr. Finlay McRae was requested to write a paper relative to the requirements of the General Land Office in the matter of running separate connection lines for mineral land surveys.

On motion adjourned. J. S. KEERL, Secretary.

THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

NOVEMBER 4, 1891:—The committee on visiting day selected this date and arranged the following:

PROGRAMME. (City Time.)

Assemble at Forest City House	6.15 P. M.
Enter dining room at	6.30 " "
Leave Forest City House	7.20 " "
And board train of Broadway and Newburgh St. R. R. which will be waiting on the spur north of the mast on the Square. Train will leave Square at	7.30 P. M.
And will leave Power House at	8.30 " "
Returning, train will leave Rolling Mill for the Square at	10.00 " "

The evening was cloudy with an occasional sprinkle of rain, but not enough to interfere with the programme which was strictly carried out, and all were highly pleased with the evening's entertainment.

A. H. PORTER, Secretary.

NOVEMBER 10, 1891:—Club met at 8 o'clock P. M. with President Gobeille in the chair, and 25 members and 3 visitors present. The minutes of the last meeting were read and approved. The Executive Board reported: Messrs. Ernest W. Naylor, Frank Aborn, and Aug. A. Honsberg, and recommended their election to active membership.

A letter from Mr. J. F. Holloway accepting honorary membership was read.

Mr. Barber for the committee on Visiting Day, reported as follows:

The last visiting day was attended by a goodly number of the Club. Forty assembled at the Forest City House where we partook of a light supper which I see our newspaper friend reported as a banquet, although we hardly considered it such. When we arrived at the Broadway train there were seventy-eight members on hand. We went direct to the Broadway and Newburgh St. Ry. Co.'s power house. We shall have an interesting account of the visit later in the evening, as Mr. Roberts has that subject in hand. I might say that Mr. Roberts had his Kodak with him, and has produced some flash light photographs which are a great credit to the artist. At the power house we were joined by two more guests making eighty in all in attendance. At the Cleveland Rolling Mill Co.'s office we were cordially received by Messrs. Walker, Reed, Skellum and Powell, and treated to cigars which were a pleasure to all present. I have no doubt but we shall have a full description of this visit to the Cleveland Rolling Mill from Mr. Gilford.

Mr. E. P. Roberts made the following report:

Before I commence this report, I would like to say in regard to Mr.

Barber's compliment to the artist, if this, the photograph, is creditable to the artist it is hard on the Club. I am indebted to Mr. Jones for the drawings, and to Mr. Palmer for the photograph of the power house.

Report of Visit of the Civil Engineers' Club of Cleveland to the Power House of the Broadway and Newburgh St. R. R.

The members who had the privilege of inspecting the power house last Wednesday arrived at 8 p. m. on a special train kindly tendered them by Mr. Horace E. Andrews, the opportunity to do so being afforded him by Mr. C. Wasson.

The writer had very little opportunity to make notes at the time of inspection, as he was busy with an effort to obtain a likeness of the distinguished men present. His effort has met with such a degree of success that upon showing the same to a friend, and stating that it was taken in Newburgh, he was met with the remark: "Poor fellows, are they all incurable?" Since the trip I have obtained the following information from Mr. Andrews, and to Mr. E. H. Jones I am indebted for the loan of the drawings.

The road was started, as a horse road, Christmas 1872, as an electric road, Christmas 1889. It now has 25.62 miles of single track (all tracks are double). The maximum grade is 6.75 per cent. for a length of 600 ft. The sharpest curve is 40°.

Track construction:—The rails are mainly (95 per cent.) 82 lb. Johnson Girder rail. On the main line 4 in. bulb chairs are used, on the belt line the rails are spiked to the ties, using heavy tie plates. The joint is the Whitton 6-bolt joint. Oak ties 7 ft. x 6in. x 8in. are used, 2 ft. 6 in. c. c. In Newurgh the roadbed is blast furnace cinders, in the city gravel and sand. Tie rods are placed 10 ft. apart.

The bonding of the track is as per sketch. The trolly wire is No. 4 silicon bronze. Suspension wire is No. 4 galvanized iron. The line insulators are the Cleveland Construction Co.'s and all line work was done by that company.

The poles are iron and steel, set in concrete.

Rolling Stock:—The rolling stock consists of 96 cars, of which 35 are motor cars, 23 Edison, 1 Westinghouse, and 11 being of the design of our well-known fellow-member, Mr. Sydney H. Short. All are double reduction motors.

One electric sweeper is available equipped with three standard Short motors, two to drive the car, one to revolve the brushes.

The most approved and latest car gear used, according to Mr. Andrews' statement, is one designed by him and combines elliptical and spiral gearings in such a manner that he is able to run a 21-ft. car with very little pitching motion. The wheel base is 7 ft. 6 in., wheels 36 in. in diameter. Mr. Andrews thinks the 21-ft. car the maximum length which will permit rapid loading and unloading and therefore not interfere with rapid transit.

The Power House.

1st. Generation of Steam:—Five boilers are in use, 72 in. x 16 ft. tubular boilers, each with 122 3-in. tubes. The boilers are built by the Variety Iron Works. Each boiler has an independent stack 62 ft. long by 36 in. diameter; following a practice not very general but in use by some of the best electric light station designers.

Two Worthington duplex pumps are used and one feed water heater built by Reynolds.

The coal is run of mine. Water can be taken from either high or low pressure pipes of the city supply system.

PIPING:—The piping consists of two mains as shown, each taking from a long header over the boiler and with valves as indicated.

It is covered with an asbestos covering.

ENGINES:—The engines are Reynolds Corliss high pressure. Three are 20x42, 88 revolutions, rated 250 h.p.; one is 28x48, 70 revolutions, rated 480 h.p.

Steam pressure is 100 lbs.

The fly wheels of the smaller engines are 16 ft. diameter. Each engine has two wheels, their combined weight being 12 tons. The large engine has one wheel 24 ft. x 62 in., weighing 30 tons.

Each engine is supplied with sight feed and pump for cylinder oiling, and the crank pin is lubricated by oil fed into a center oiler.

The foundation is brick laid up in cement and rests in a clay soil.

All oil caught is passed through a washing filter.

TRANSMISSION OF POWER TO THE DYNAMOS:—This is the most characteristic feature of the plant and is due to Mr. Andrews. Each engine drives two dynamos by direct belting, in the manner so often used with high rotative speed engines, but seldom, even now, with drop cut off engines. To discuss this point would make my paper other than a simple report and, interesting although it is, I will not dwell upon it at this time.

THE GENERATORS OF ELECTRICITY:—Dynamos for power work are usually termed generators. Each smaller engine drives two No. 32, 80 kilo-watts Edison generators. The larger engine drives two No. 60, 150 kilo-watts machines.

THE SWITCH BOARD:—In the board used the rheostats and the individual ammeters and cut-outs are brought to the same place as the feeder ammeters and cut-outs. The ammeters are standard Edison and the cut-outs the Cleveland. A Weston voltmeter is used. All are assembled on a handsome slate backing 20 ft. x 10 ft. and placed three feet from the building wall.

The wiring is on the back of the board. Wirt, Cleveland and Wason lightning arresters are used.

The power house is under the same roof as the repair shops. The repair shop has not any transfer table, switches being arranged as shown.

PERSONNEL:—About 200 men are employed by the company, the officers of which are:—Mr. Horace E. Andrews, President; John J. Stanley, Vice-President; Edwin Fowler, Secretary, and to them I desire once more to express my obligation for their courteous treatment of an amateur reporter.

Respectfully submitted, E. P. ROBERTS.

Question: I would like to ask if you ascertained the cost of the machinery?

MR. ROBERTS:—No, I did not ask the question. I did not want to ask questions about anything but what I was sure they were willing to have made public. I should judge that the cost was about $55.00 a horse-power for the steam plant. Mr. Andrews asked me what I wanted to know, and I answered that I only desired such information as I could make public and, therefore, financial matters were not reported.

Mr. Geo. E. Gifford reported as follows:

A Page of History Relating to the Cleveland Rolling Mill Company's Plant.

I am not responsible for the title of this report, but must congratulate the gentleman from whose brain it emanated upon his happy choice of words, for this must necessarily be but a "page" from what might be a large volume in regard to this monster industry within our city's limits.

The "page" thus taken from the "history" will be of very recent date, going back less than a week, and will narrate the visit of the Civil Engineers' Club of Cleveland, to the works of the Cleveland Rolling Mill Company on Wednesday evening, November 4, 1891, giving a *resume* of the things they then saw, and touching possibly upon some things they did not see.

After having visited the power station of the Broadway & Newburgh Electric Railroad Company, the engineers and their guests were received at the office of the Rolling Mill Company, by Messrs. Henry Grey, General Superintendent; John Walker, Superintendent; Henry Barren, Master Mechanic, and a member of this club,and Lewis T. Powell, Private Secretary to Mr. Chisholm. After such of the members as were "addicted" had been regaled with nicotian refreshments, we were conducted into the mills by Mr. Powell.

Here it is my purpose not to follow the visiting party further, but to leave them to wander through the rod mills, bloom mill and yards, while we to-night will begin at the beginning and follow the material from converter to coil of wire. We should properly begin at the blast furnace, but as this was not visited by the Club, and its operations are familiar to all, we will begin at the Bessemer steel converters.

The Bessemer plant of the Cleveland Rolling Mill Company was, I believe, the third constructed in this country. It is by no means the largest now in operation, still it has a capacity of 700 gross tons per *diem* and produces a very good quality of steel. The capacity per heat for each converter is about 8 gross tons. The pig iron is mostly produced at the blast furnaces of the Company. This is melted in ordinary cupola furnaces and run into the converter after having first thrown in some crop ends of billets, or rails. This both uses up otherwise useless material, and cools the bottom of the converter so that when the blast is turned onto the molten metal too fierce heat is not generated. The evening we were there they were producing a "low" or soft steel; for that reason the addition of spiegel-eisen after the de-carburization, which is usually made for "high" steel to bring it up to the proper degree of hardness by adding a certain proportion of carbon as well as of manganese,was omitted, but an addition of about 75 hundredths of one per cent of ferro-manganese in the form of broken pig was made after the steel had been poured into the ladle. This does not add materially to the carbon in the steel, but gives that proportion of manganese which is necessary for the production of a good grade of steel.

It may be of interest to know just what manganese does for steel, so I will quote from Howe's *Metallurgy of Steel*; "Manganese prevents hot-shortness in steel by preventing formation of blow holes, by reducing or removing oxide and silicate of iron, by bodily removing sulphur, by counteracting the effects of the sulphur which remains as well as of iron oxide, phosphorous, copper, silica and silicates."

The steel is poured from the converter into a ladle large enough to take the entire contents of the converter, which is supported and operated by a hydraulic crane of 20 tons capacity, working in a circular pit, around the sides of which stand cast iron molds to receive the molten steel from the ladle. After the steel has cooled sufficiently to be handled, the molds are lifted from the steel and there stand the red hot "ingots" of Bessemer steel. These are lifted by cranes of 5 tons capacity, three in all, so placed as to command every portion of the pit, onto small cars or "buggies" with four wheels and a platform of rails, running on a standard gauge track and hauled by small locomotives. The ingots are 14x16 in. at the butt, and average in weight about 3,000 pounds. The pressure of 450 pounds per square inch for the hydraulic cranes is produced by six Worthington pumps located in the engine room and probably not noticed by most of us at the time of our visit. The 25 pounds per square inch air pressure for the blast is produced by two horizontal blowing engines which have been in use twenty-five years, although they have been repaired and strengthened in the meantime. The fuel in use under the boilers is crude oil. The oil burner is one manufactured by the Company for its own use.

From the steel works the ingots are taken, without being allowed to get cold, to the blooming mill, there re-heated, rolled and sheared into blooms 7x7 in. weighing about 750 pounds each, which without re-heating are again rolled into billets 3x3 in. or 4x4 in. weighing all the way from 30 pounds to 150 pounds, according to the use for which they are intended.

From the blooming mill the billets go to the rod mill, are re-heated and rolled into No. 5 rods ready to go to the wire mill. In the new rod mill which was the second visited by us the other night the 4 in. billet is rolled by 18 passes in a duplex repeating mill to the finished rod. The "repeating" part of the mill consists in the fact that certain of the "passes" are made automatically. From the first to the sixth, the passes are made by hand, from the seventh to the eleventh they are repeated by the machine without assistance from the operators, the twelfth pass is made by hand, and from this to the eighteenth or last, each alternate pass is made by hand. After the last pass the rod enters a hole in the center of a revolving wheel or disc called the "rose-bitt." From this central hole radiate several other holes so that on the opposite or outside of the "rose-bitt" there appear several holes, while on the inside there is only one. The rose-bitt is about 7 in. in diameter and 6 in. thick, of cast-iron, and its revolutions are regulated by the speed of the rolls. As the rod driven by the rolls enters the central hole, finding no other means of egress it continues on through one of the radial holes, no matter which, and thus receives in addition to its rectilinear motion a circular motion from the "rose-bitt" which two combined just nicely throw the rod over and wrap it around a peculiar conical shaped reel called a Tallman reel from which it is taken in coils by boys with long tongs hung from overhead runways. This mill is called a duplex mill because two or sometimes three or four rods can be in the rolls at the same time. Continuous mills are in use which are entirely automatic after the first pass, but it is claimed that the duplex repeating mill has a greater capacity because of its being able to roll several rods at once, which the continuous mill cannot do.

The old rod mill, the one first visited by us the other night, is also a repeating mill but has not the Tallman reels, the coiling being done on an ordinary power reel. This mill is used for the manufacture of spring steel and the finer grades of wire. The Cleveland Rolling Mill Company

is the largest manufacturer of rods in the United States, the daily output being 400 net tons.

From the rod mill we go to the wire mill where we see the No. 5 rods in coils taken in charge by a most ingenious machine the invention of Mr. Wm. L. Hayes, Assistant Superintendent of the wire mill, which automatically prepares the rods for drawing. Unfortunately the machine was not shown to the Club on the evening of our visit as it was in another building from those we visited, and as our time was then growing short we did not get to see it. Nor can I attempt to describe it here but will say that the members of the Club, individually or collectively are invited to visit the mills and see the machine for themselves. The preparation of the rods consists first in a bath of hot dilute sulphuric acid which removes oxide of iron scales, leaving a clean smooth surface, then a bath in cold water to wash off the acid and loose dirt that may still remain, then a spraying with clean water to give it the so called "water coat," then a dip into a thin paste of lime and wheat flour to give a sort of lubricant to the rod that in the drawing it may receive a smooth finish and not be scratched and rough, as well as to preserve the dies. After this the coils are carried along to an oven where the coating of lime and flour is dried and the rod is ready for drawing. The machine I have mentioned performs all these operations with only one handling of the rods, that of placing them on trucks ready for the machine to take up for the initial operation.

When we consider that ordinarily these operations are performed, one at a time, in a series of vats containing the various baths, by successive dippings with a crane, we appreciate what a labor saving device the machine is.

For drawing, the coil of rod is placed on a reel on the floor, the end pointed in a machine making a curious buzzing noise that excited the curiosity of some of our members the other evening, and then started through the die and wound onto another reel placed on the bench before the operator. The die is of cast iron with taper hole. As the hole wears it is reamed out for a larger size. Some of the dies for fine wire are of steel and as the hole wears it is hammered down on the back side and the hole reamed the same size as originally. The wire is generally drawn down to about No. 12, before annealing. The annealing is done in a "muffler" heated by coke. The larger sizes of wire are drawn "dry," but the smaller sizes are drawn by the wet process. By this process the wire passes through the die from a bath of sour flour and water; the wet drawing is done in the room which reminded some of us who were brought up in the country of the old pig pen.

Comparatively little wire is sold for commercial purposes without some coating to prevent rusting. This coat may be of brass, copper, tin or zinc, the last being called galvanized wire.

The brass coat is applied by dipping the wire in a solution of blue vitriol and some salt of tin. The copper coat is formed by dipping the wire in a solution of blue vitriol alone. The wire is then drawn again so as to polish the plating.

For the tinning process the wire first passes through dilute hydrochloric acid to thoroughly clean the wire and cause the tin coat to "set," then through a bath of molten tin. After coming out of the bath the excess metal is wiped off by passing through cotton.

The galvanizing process is similar to the tinning except that the bath is of molten zinc and the wiping done by asbestos ropes. The coarser

wires such as for fence wire are galvanized while the finer wires as for the manufacture of picture cord are tinned.

The Cleveland Rolling Mill Company does not make any telegraph wire as this requires a very fine grade of Swedish iron. The principal manufacturers of telegraph wire in this country are Washburne & Moen, of Worcester, Mass., and John A. Roebling's Sons, Trenton, N. J.

A report of the Engineers' Club's trip to the Rolling Mill Company's works, would not be complete without mention of the new blooming mill now in course of construction but which is so far advanced that we saw them roll some slabs in it. It is said that this mill will be the completest of its kind in this country when finished. In it they will roll billets 1½ in. x 1½ in. from the ingot with only one heat. They will roll 12 in. x 12 in. blooms and 8 in. x 20 in. slabs all of which will be sheared by hydraulic shears. After the first of January next they will be prepared to furnish all sizes of channels up to 12 inches and after March first all sizes of I beams up to 12 inches. This mill will also produce rails. The heating of the ingots will be by means of what are called soaking pits, the fuel being gas.

The Club has a very cordial invitation to visit the Rolling Mill Company's plant again when this mill is finished and for fear some may think it hardly worth while to go so far to see this one mill I will say that in addition to this and the other mills we saw on our previous visit, the Company operates three blast furnaces, another rod mill, an 18 in., 12 in. and 9 in. merchant mill for the production of angles and merchant iron, a puddle mill, bar mill and plate mill at which last are rolled universal and sheared plates and sheet iron and where they make corrugated iron both black and galvanized.

Before taking the cars for home the Club and its guests gave three hearty cheers for the officials above mentioned who by their attention and courtesy had made our visit so pleasant and profitable, and three more cheers for the Cleveland Rolling Mill Company, for its kindness in extending the invitation to visit its immense and instructive plant.

GEO. E. GIFFORD.

PRESIDENT GOBEILLE.—*Gentlemen:*—I know you will bear with me if I add just a few words on this subject. I have been interested in Mr. Gifford's excellent report, which has been presented in a very happy and able manner, but I want to go back a little farther than he has gone, and look at the men who originated those things which we saw and of which we heard.

At the head of the list of members in the catalogue of the American Society of Mechanical Engineers' appear the names of two men who are styled "Honorary Members in Perpetuity." One of these men, Mr. H. R. Worthington, has left a name and impress on mechanical pursuits, especially hydraulics, which will never be effaced. I do not wish however, to speak of him to-night, but of the other name; Alexander Lyman Holley. When I stood looking at the converter bellowing forth its flame and starry fragments, at the Cleveland Rolling Mill Co.'s plant the other night, my mind went back to the time when it was built, which was, I think, in 1867, it being the second Bessemer plant put in operation in this country. It was thought by Mr. Holley that six turns a day could be expected of this plant. What a change in a few years; the same machinery, the same hydraulic cranes, except perhaps, the center crane, everything just as origi-

nally designed, now doing as high as eighty turns every twenty-four hours:—more than that, the original converters were five tons, they have been increased to eight tons, and yet, with this wonderful performance fresh in my mind, the thought that comes to me to-night is one of sadness:—What would not Alexander Lyman Holley have given to live to-day and see what we have seen? And with what temerity would we look forward to the outcome of our efforts if, upon designing a certain machine or system of machinery to do a given quantity of work in a definite time, it should be found that the result was multiplied fourteen times beyond our fondest hopes.

There has been some talk, I understand, of transferring the Bessemer Mill to another site and installing a new plant, but Gentlemen, if that day comes, I shall look upon the change with anything but pleasurable feelings. But Mr. Holley's work was not all. Going a little farther into the rod mill, we saw, making as good an output as almost any mill in the country, the first duplex mill built by Mr. Robert Garrett.

I remember sitting at dinner with Mr. Garrett a year or two ago, and hearing him refer with pride to his early efforts, and this was the first Garrett Mill. Without going into personalities for comparison, I can say with sincerity, that I am glad because of the success of the first Garrett Mill. I know of a place where a similar one, and a continuous mill, stand almost side by side, and the output is said to be variable between the two, according to the make up of the gangs employed to run them. But we didn't stop even at the rod mill: going a little farther we came upon a huge engine, and I could not help thinking of the man whose name that engine bears. So genial, so generous, so full of sympathy for every one, often to his own hurt, and there came before me a picture of the man as I last saw him. All his hopes and ambition seemed to be approaching fruition. He was cheerful and happy, though ill and in bed. A few days after that he took up one hand with the other as he lay there, and looked at it intently; there was no feeling in it, and he knew it must be paralyzed. He said not a word, but turning over in the bed with his face to the wall, in fifteen minutes he was dead.

Homer Hamilton struggling through life, doing what would be thought wonders now in a mechanical way, had given up at last and died a poor man. The establishment which he founded, and which was at that moment on the high road to success, has become the great Hamilton Works, at whose shops this Porter-Hamilton engine was built.

Gentlemen, do not consider what I say to be in any sense supplementary or any addition to Mr. Gifford's valuable report, but looking back of what we saw on that evening (which I am sure will always remain among our pleasant memories,) I saw the *men* and having known them, I have unwittingly paid them this poor tribute.

The paper of the evening was by Prof. Frank H. Neff entitled French Roads, their administration, construction and maintenance. It contained an elaborate and detailed account of the system according to which these celebrated roads were constructed, their cost, the way in which they are kept in repair, and the care and pains taken to maintain them in their present high state of excellence. This was followed by a discussion in which a number of members took part. Mr. Palmer offered the following which was unanimously adopted.

Resolved: 1st. That the thanks of the Club be extended to Mr. Horace E. Andrews for furnishing a train of cars for the use of the Club on

the occasion of its recent visit to the power house of the Broadway & Newburgh St. Ry. Co. and for other courtesies.

2nd. That the thanks of the Club be extended to Mr. Wm. Chisholm and other officers of the Cleveland Rolling Mill Co. for courtesies shown on the occasion of the recent visit of the Club to the works of the Cleveland Rolling Mill Co.

On motion adjourned. A. H. PORTER, Secretary.

WESTERN SOCIETY OF ENGINEERS.

286TH MEETING, DECEMBER, 2, 1891:—The 286th meeting of the Society was held at its rooms, Wednesday evening. December 2nd, 1891, at 8 p. m. President L. E. Cooley in the chair and 55 members and visitors present.

The minutes of the previous meeting as printed were approved.

The Secretary reported, for the Board of Directors, the following elections to membership: Messrs. W. W. Curtis, Henry Hauser, Prof. Chas. B. Wing, Pitney F. Randall, Berney B. Colborne, E. L. Cooley, Geo. D. Hersey, John B. Price, Wm. B. Ewing.

Mr. W. J. Karner, for the committee on "Badge, Seal, etc.," reported that the committee were awaiting designs, little response having as yet been received to the request made in the November proceedings.

The Secretary read a letter from Mr. E. L. Corthell, now in Mexico, informing the Society that Mr. M. Fernanadez Leal, President of the Mexican Society of Engineers and Architects, had presented the Society with some valuable maps and charts of Mexico. The Secretary was authorized to acknowledge its receipt and express the thanks of the Society.

The President called attention to the Annual Meeting and asked for action on the subject.

Mr. J. F. Wallace moved that the Annual Meeting be held as usual on the first Wednesday in January and that a committee of entertainment be appointed. Carried.

The President remarked that last year's committee had done so well that it would be wise to continue their services, adding thereto the name of the first vice-president. Committee: John F. Wallace, H. C. Alexander John Lundie, Wm. J. Karner.

The President called attention to the new By-Laws relating to the election of officers which were now in force.

Mr. C. T. Purdy presented a resolution which after amendment by Mr. Gottlieb to insert "wrought iron" and "cast iron," was seconded and carried.

The following is the resolution:

RESOLUTION.

WHEREAS the introduction of steel into the construction of buildings during the last few years has wrought an entirely new departure in architecture, involving new methods of construction and larger possibilities of design both in size and style; and

WHEREAS this has introduced a new field to the engineering profession and raised questions in many quarters as to the strength, durability and protection against fire which steel buildings offer, in all of which the business interests of this city are greatly involved; and

WHEREAS there is great need of further and more definite knowledge pertaining to this subject, therefore:

Be it resolved: That this society appoint a special committee of five members to make investigations and tests on the following lines.

1st. The nature and action of the clay strata underlying Chicago with reference to the foundations of large buildings.

2nd. The strength of columns, cast iron, wrought iron, and steel of sizes actually used in building construction, and the effects of excentric loading.

3rd. Fire proofing and its efficiency and the effects of moderate degrees of heat on iron columns and beams.

4th. The rigidity of steel buildings and what should be required in the way of lateral bracings.

In introducing the resolution MR. PURDY said: I offered this tonight for the purpose of making suggestions rather than with any desire to push the matter. It seems to me that the importance of steel in the construction of buildings is hardly realized by a majority of the profession, to say nothing of the people outside of the profession. It is beginning to take a very large place in steel manufacturing, and a very large place in the profession too, at least here in Chicago, and while there are many questions of large importance being considered every day, we are actually in need of a very great deal of information that we have not. We need practical tests. We need more practical knowledge of what we are dealing with in a large measure theoretically, that can only be obtained at the expenditure of much work and a great deal of cost. The money cannot be raised today unless the work is handled by some agency which can practically guarantee reliability, honesty, accuracy and thoroughness of work. It seems to me that that guarantee might be furnished by this Society. It seems to me that we might be able to find the men that could do the work. I think that there is no other question that this Society has ever handled or investigated that touches so many people, or so many public interests, as this. I believe that as much money can be raised to investigate this matter in a way that it has never been investigated before, as any other subject that we can take hold of. It cannot be done in a short time; it will require considerable time.

The manufacturers of iron, the builders, architects, the moneyed men of our city, those who are investing in buildings of this nature, those who are connected with the manufacture of fire proofing, and so far as the effects of fire on these buildings go, all the public are interested in it, and indeed there is scarcely any important industry in our city that is not in some way touched by it. It does seem to me that it would be a proper subject for this Society to take hold of it in the coming year. I do not know that now is the proper time to appoint that committee, but a great deal of discussion has been going on in the papers which is false; so many things have been written which if false or true cannot be proven, even those positions which men have taken in regard to steel buildings are to a large extent unprovable and cannot be demonstrated as we can demonstrate a great many other things in other branches. The question of excentric loading is a thing we know very little about practically,—we are dealing with it theoretically. It is a very important matter in building construction. It is because these things are coming to me every day in my own business, because I am touching them all the time, that I have come to think more of them and have come to the point of making the suggestion contained in my resolution, to this Society.

MR. F. C. ROSSITER spoke warmly in favor of the resolution.

PRESIDENT COOLEY said the resolution was in line with the policy pursued by the Society for the past two years, but thought it would be proper for the motion to lie over and be printed, in the meantime affording time to consider how best to appoint the committee so as to get the desired results and to give further opportunity for further debate.

Mr. Purdy agreeing with the President, and no further objections being made, action was postponed.

On motion of Mr. Benezette Williams the discussion of Mr. Gottlieb's paper, "The Foundations and Floors for the buildings of the World's Columbian Exposition," was first put in order.

Written discussions from Mr. T. G. Gribble, A. M. I. C. E. and Mr. Onward Bates were read by the Secretary, and these were followed by oral discussions by Messrs. Chanute, Wallace, Cooley, Horton, Benezette Williams, Maddock and Bridgman.

Before proceeding further the President said: I think this question has been a very interesting one, and believe I expressed the wish of the Society in leaving it open. I think there are number of you here who ought to express your views and put them on record in regard to this matter. It brings up the whole question of timber structures and foundations upon our soil here. Those are the two matters which the discussion has especially brought out.

The adjourned discussion on Mr. Corthell's paper on "An Enlarged Water-Way between the Great Lakes and the Atlantic Seaboard," was next taken up.

The Secretary read discussions from Mr. Wm. Pierson Judson, of Oswego, New York, and Mr. Samuel McElroy, and other discussions on hand will lie over to be put in type with them.

In closing, the President, in referring to the discussions remarked:

I believe there are one or two other papers which we will not bring up tonight. There is one paper by Mr. Goodwin in which he takes views somewhat similar to Mr. McElroy in regard to the use of vessels at 15 feet depth. Mr. Goodwin has been recently one of a commission to establish the ship canal from Lake Erie to Pittsburgh, a project of a great deal of merit, and his paper maintains that that depth in that ship canal is sufficient for the purpose. I was going to say that the Society will regret to hear that since Mr. Goodwin forwarded his paper to us he died somewhat suddenly at his home in Sharpsville, Pennsylvania. He has been long known in connection with the question of rapid transit on canals by means of canal towing and other means.

On motion the meeting adjourned.

John W. Weston, Secretary.

Editors reprinting articles from this journal are requested to credit both the JOURNAL *and the Society before which such articles were read.*

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This Association, as a body, is not responsible for the subject matter of any Society or for statements or opinions of any of its members.

THE CIVIL ENGINEER.

AN ADDRESS GIVEN AT THE ANNUAL MEETING OF THE WESTERN SOCIETY OF ENGINEERS, BY REV. CONRAD HANEY.

[January 6, 1892.]

It is needless to say, Gentlemen, that I am somewhat embarrassed in this presence, for the civil engineer is altogether a mystery to the ordinary man. We are well acquainted with your thought, as it rises in massive edifices, or cleaves its way across continents and over the mountains and seas in those remarkable works that are the very highest exponents of the advanced civilization of today; but you yourselves, thinking in the study, observing on the fields where soon you expect to conquer, and in general laying plans to circumvent nature and turn the world quite upside down, seem to covet retirement from the popular gaze. And when suddenly therefore, I come face to face with more civil engineers than I ever thought of before, although you look a good deal like regulation mortals and seem to have appetites that are unanimously human, it is only natural that the timidity characteristic of the ministry, and hereditary in my family, should quite overmaster what strength my heroic onslaught on the dinner table has left me. But I take courage in the thought that I'm something of a civil engineer myself; for who have tunnelled through more mountains or bridged more rivers, or constructed more roads than the preachers, in their effort to make transportation to the realms beyond as safe and easy as, unfortunately, it is rapid. Show me, if you can, drawings of an elevated road that is not very low and very narrow in presence of the Methodist highway. Where have you

devised a tunnel that will not metaphorically "hide its diminished rays" before the shaft that Universalists and Unitarians have driven straight through the theological mountains that generations had been forced to climb? Let me ask you in all seriousness, if the Hennepin canal scheme can compare with the Baptist waterway, or our astute drainage commissioners devise such a disposition of the sewage of a great city as the Salvation Army? Why Gentlemen, now that I bethink myself, I'm quite at home in your midst to-night, and altogether inclined to receive all of you into full fellowship. Having thus established my position in the profession in a way that I trust is entirely satisfactory to us all, permit me to say that the real meaning of our work first dawned upon me some three years ago, in the Republic of Honduras, as I rode upon the overland express of the Honduras and Inter-Oceanic Railroad. May I describe this flyer? First of all was a wheezy little old engine, at the throttle of which stood a driver (we engineers call him nothing else) as black as Erebus, but the very soul of good humor. Two natives sat in front, where the pilot had once been, with a box of sand between them, which they applied to the track as occasion demanded. Back of the engine, were a few of the most unutterably forlorn looking old flat cars that the eye of mortal ever saw, where the second class passengers rode in the boiling sun with the freight. The train concluded with the first class coach. A century old it seemed, for every joint yawned and all the windows were broken. A long wooden bench stretched from one end to the other on the larboard side. A similar device had ornamented the starboard side when the morning stars sang together, but at the time of my visit, lay prone amidst the cigar stubs and broken pottery with which some generations of Honduras travellers had strewn the floor. There was not a brake on the entire train or a car that seemed able to move without falling to pieces, and I doffed my hat before the hoary old ruins with a reverential awe that my accident insurance policies did not ameliorate. The conductor of this rare aggregation of antiquities was a tall, sunburned specimen of humanity in linen clothes and straw hat who hailed from Chicago, as genial, as honest and as lazy a man as ever pulled a bell cord or punched a ticket. He looked and acted as if born with his train, seemed just as likely to fall into pieces, and fitted into the hot sun and waving palms of the tropics as nicely as though the energy and push of great Chicago had never warred about him. Well, after an amount of whistling that left only steam enough for an asthmatic wheeze, the little engine pulled out of the station. We soon stopped, however, to fill up the sand box on the pilot. Another move, and we stopped for wood. Then we stopped while the conductor hunted up a carpenter, and gave him time to repair the first class coach. We stopped for water. We stopped to give me an opportun-

ity to take some photographs. We stopped for dinner. We stopped while the conductor escorted a drunken passenger to his home hard by the railroad track, and had a little visit with the family. We stopped to get the train on the track. We stopped to get a drink. We stopped just for the fun of the thing. Why there were more stops to that train than to any grand organ that I ever saw, and at every stop when we were ready to get under way, the little old engine whistled itself into the whooping cough, and the big conductor ran around in the woods or through the village as the case might be, and escorted us back to the palace car. But the road bed! O! shades of Eads and Cooley and all the rest of us! That's what gave me a passion for engineering. It danced up and down like a Norman colt on a frosty morning. It dodged in and out in a way that made me dizzy to contemplate, and the iron lay upon it in angles and curves that resembled the handwriting of Horace Greely. But like the Cunard line the Honduras and Inter-Oceanic has never lost a man, and with unswerving faith in destiny, I held on while the old caboose squeaked and rattled and thumped and banged and stopped for nine mortal hours over thirty-seven miles of jagged iron. Talk about the blue laws, witch burning and the inquisition! The civil engineering that evolved a road like that, that will lacerate a man's body and harrow his soul and destroy his piety, that will set his head and stomach to aching and make him sea sick and home sick and heart sick, if not worthy a place beside the most lurid theology of the time, is at least well fitted to attract attention, and it was months before I could meet a civil engineer without having a good deal of sympathy for myself.

Two weeks after I stood upon the banks of the Rio Copan, looking upon such a scene as I had never faced before. Round about me towered huge stone monoliths, in exquisite design, and to my right, there rose above the river, a massive pyramid of cut stone that seemed companion to the mountains that looked down in rugged majesty upon the scene. All about me were crumbling walls, running off in every direction through the dismal solitude of the tropical forest, and for miles the country was covered with shattered pyramids and broken columns and pieces of figures and carving. There was no human habitation near, nor trace that man had made his abode in that neglected desolation for many a century. As I rode into the ruins of the once splendid amphitheatre of the wonderful temple, three wild deer were feeding amidst the broken fragments of the art that had made it exquisite before Abraham left Ur or Pharaoh worshipped Isis. There are records of great Rome, of queenly Tyre and cruel Carthage. The bricks of Babylon tell some story of the hands that heaped them into magnificent vastness. Egypts pyramids and paintings are vocal with the thought of ancient priest and king. But there, in the solemn magni-

ficence of a tropical forest, beneath the waving palms and giant trees that shroud them in eternal gloom, as voiceless as the grave and mysterious as death itself lie the mangled ruins of an empire whose very name has perished from the earth. I clambered up to the summit of the temple and looked beyond the valley in which that mysterious past is buried. Everywhere were the mountains. Giant behind giant! Land billow heaped upon land billow in the very perfecton of infinite chaos. Why it seemed as if in the years agone the earth had melted from the unseen fires beneath, and boiled, until the land on which I looked was a monstrous chaldron, rocking and heaving and roaring until its infernal billows tossed their ragged crests against the sky, and then, in an instant, a cold breath from the mouth of God had turned them into granite as they were, and left them yawning in their rigid death, until kindly nature pitying the sterile waste, had painted it in red and white and green and gold, and melted all the bald sublimity of the scene into a sea of color. This, all this was God's setting to the single human thought that had defied the centuries. Science had perished. Literature was buried. Art was obliterated and even religion had faded from tradition. Earthquake and tempest, and fire, the whirlwinds of savage war and none know what beside, had swept the empire, and century after century, had buried it deeper and deeper yet in oblivion, but still unmoved, and today akin to eternity, out of it all rose the aqueducts, the walls and the huge old temple, the imperishable thought of the civil engineer. Centuries before the red man began chasing the bison over the prairies of this continent, perhaps centuries before history was thought of, there lived between these oceans an innumerable people. far advanced in all that goes to make a civilization. The altar fires of a great religion shone from the Rockies to the Alleghanies over the busy millions who toiled in the fields, or labored in the crude manufactories. The rivers carried commerce from the lakes to the gulf, and armies garrisoned fortresses upon the hill tops or marched to meet and conquer from the north to south. How do we know this? Religion? It has perished. Science? It has perished. History? It has perished. Tradition? It has perished. Everything has perished and the knowledge of the race would have followed the race itself, but for the mines, the limitless embankments and the huge old mounds, the outputtings of the immortal thought of the civil engineer. What light do the conflicting lists of unpronounceable king names shed upon the morning splendor of Egypt? You must stand and read the thought of the civil engineer, as it towers in the giant pyramid, if you would understand her greatness. What do we know with certainty of infant Babylon, until we turn from the bewildering mass of contradictions that we have been taught to call history, and begin to study the thought of the civil engineer on the banks of the Euphra-

tes? And last of all, Gentlemen, and in my eyes it lends supernal dignity to your honorable profession, how could we establish the truth of our sublime old testament, had not civil engineers clothed their thought in stone and earthwork, to rise up in the nineteenth century with a grand amen, to the truth of God. The orator writes his thoughts upon human hearts. The philosopher engraves his ideas in human lives. The artist puts his being upon canvas and the poet and the scientist transcribe their thinking on the printed page. History is only type and ink and tradition human memory. But hearts cease to beat and lives go out. Canvas moulders to decay and books soon perish. But earth and granite and iron and oak and steel that knit themselves together to mirror the mind of the engineer, they are eternal.

Did time permit, I should be glad to refer to the magnificent work that you have done. The railroads, those links of steel that marry the oceans; the colossal bridges, whose massive weight you have founded upon stability below the river sands; the wondrous shafts through granite mountains and under straits and rivers, to relieve the congested veins and arteries of commerce; the harbors and the water ways; all those splendid triumphs that your tireless thinking has acheived, until it seems as if you had harnessed boundless Nature to your work. Sometimes we ascribe these monuments to the capital that pays for the dirt that is digged and the rocks that are piled, or fancy that they who seem to control the mechanical details deserve the mead of praise. That which we see and hear often fills our thinking till we overlook the fact that the omnipotent forces are the unseen and silent ones. Earthquake and tempest and fire and flood are childs play beside the solemn grandeur of gravitation that, all unseen, makes unity of the tangled splendor of a blazing universe. No greater is the hod carrier, the contractor or the capitalist in presence of the engineer. From the great pyramid to the Brooklyn bridge, all material monuments of civilization have been builded in the brain of a thoughtful man unseen and often unrewarded of the world, before common labor brought them to the public view in stone and earth and steel. And when, in years to come, another age looks on these works of yours, the inquiry will be, not who builded, but who devised, and the honorable tribute will be laid at the feet of him whose thought made these monuments a possibility.

BRIDGE LEGISLATION.*

REPORT OF A COMMITTEE OF WESTERN SOCIETY OF ENGINEERS.

DISCUSSION.

HORACE E. HORTON,—FEBRUARY, 3, 1892.

We find in the report of the Committee on Bridge Legislation the statements:

(1) "It is with the highway bridges that the greater risks of disasters have been incurred."

(2) "In the rural regions, highway bridges are constantly breaking down."

(3) "An unusual load or combination of unfavorable conditions to cause their collapse."

(4) "County authorities are frequently gullible."

(5) "Road roller."

(6) "Pools."

(7) "To this unsafe condition of affairs there is but one remedy. It is to follow the foreign example: to place the building and maintenance of highway bridges in the hands of expert bridge engineers, and to hold them responsible for the results. In other words, in order to secure safe bridges for the public, the owners of such structures must be compelled by law to intrust their construction and supervision to competent persons. This is what has been done in European countries, and this is what will have to be done in the United States."

With the hope of showing that this whole subject of demand for highway bridge legislation, as it appears in the United States, is an out-growth of misdirected energy, with disposition to serve private ends, coupled with little or no knowledge of the subject under discussion, the following is presented:

(1) "It is with the highway bridges that the greater risks of disasters have been incurred:" Say the committee.

In support of this statement, they speak of the fact that in 1873 (18 years ago), The American Society of Civil Engineers appointed a committee, as a means of averting bridge accidents; also sundry persons have drawn up acts, etc., for the regulation of the business of

* See issue of November, 1891.

building highway bridges. All this is presented to establish the fact that the highway bridge is less safe, under its traffic, than the railway bridge.

Let us investigate.

I have never seen or had my attention called to a highway bridge using metal to unit strains, of 20,000 lbs. per square inch:—I have never seen pins bent in a highway bridge;—have never known rivets to shear in a highway bridge.

It is difficult to find a railroad without bridges, in current use, with metal strained to 20,000 lbs. per square inch, also pins and rivets out of condition.

There are, at least, ten times as many highway bridges in the country, as railway bridges. With this disproportion of numbers, while (as our committee state) several of our states have found it necessary to regulate the building of railway bridges, none have interfered as to the building of highway ones. It is the "Logic of Necessity." Railway bridges have failed, and the highway one has not.

I will attempt to locate ten failures of railway bridges to one failure of a highway bridge, within a term of ten years past. This makes the percentage of railway bridge disasters over one hundred times as great highway ones. Those that result fatal to human life are even much greater.

What a field would the railway bridge disasters furnish for some tireless and persevering party, with the quality, which has been fitly termed "pernicious activity," and so energetically displayed by the commentators on highway bridge building.

The committee have made quite the usual mistake of assuming the working loads of railway and highway bridges, as two to one, instead of twenty to one, as they are.

Look at a 100 ton locomotive, and then at the farmer's team and two horse wagon.

Increase the strength of railway bridges by a ratio of ten, or divide by ten your standard for a highway bridge.

The gauge of comparison, as between the railway and highway bridge, is the committee's work not mine, however, as I find it convenient, shall use it freely.

(2) "In the rural regions, highway bridges are constantly breaking down."

No one has shown or can show the actual failures of enough highway bridges, within any given period, of five, ten or fifteen years, to justify suspicion of the highway bridge as a class.

If the committee have observed the newspaper accounts of this class of failures, as they indicate, it surely would not have been out of place for them to have brought to our attention ten, five, two or

one such statement of failure. I challenge the committee or others for data, showing failures of highway bridges.

It would have been instructive, if the committee had instanced more than one failure, and that of some twenty years ago: of the days, when, both, in the highway and railway bridge practice, it was accepted that a patent right overcame the force of gravity.

If one were going back in history, the failure at Ashtabula, surely, will overmatch the Dixon one. St. Charles, Missouri, furnishes an example, with which there is nothing in the highway business to compare,—either in the matter ef breaking down or the reports of the experts.

Surely, if "highway bridges are constantly breaking down," some one can locate the disasters more definitely, than observing "newspaper reports." Facts would be useful in support of as broad a statement as this of the committee.

(3) "An unusual load or combination of unfavorable conditions to cause their collapse."

No one will question this proposition of the committee's that the highway bridge will fail. It is the assumption that the highway bridge, and the highway bridge alone, is the only structure, which must be able to withstand a "combination of unfavorable conditions," that is objectionable, it is not fair to expect more of the highway bridges, than any of the other works of man.

Even the works of God only await the same "combination of unfavorable conditions to collapse."

From my observation of human works, it is accepted, that, if probabilities are fully provided for, chances may be taken with possibilities.

What more than probabilities are provided for in the railway bridges, even those built under state supervision?

If there is a necessity calling for bettering our bridge structures, is it not in the direction that the passenger in the railway coach shall have, approximately, the same chances with a train derailed on a bridge, as though the accident occurred on level ground? Yet, the fact established, that the train is merely off the rails on a bridge is accepted, without question, as sufficient cause for a collapse, without inquiry as to the strength of the bridge itself, and it is rebuilt, ignoring the possibility of the same "combination of unfavorable conditions" etc.

Which is likely to occur first, railway trains off the track on 1000 bridges, or one highway bridge with load of amount as specified by the commentators? I believe that a careful investigation of this proposition will be somewhat in the way of a liberal education to those engineers who have been watching for highway bridges to fail, when the humiliating fact remains that they have not.

(4) "County authorities are frequently gullible," which is undoubtedly true.

Observation would lead me to conclude that there are other persons "gullible."

The bible tells us of the party who "stood and prayed thus with himself: God, I thank thee that I am not as other men are."

It happens that we have the same class of individuals on earth at this time: in how many walks and callings of life he may be, I know not, but I know him to be in the bridge business. He carries, as a large proportion of his capital in business, the assurance that his works are perfect, and that certain other parties' works are very disreputable.

It may be a pertinent inquiry, to ask how much of the committee's knowledge of the "gullibility" of county authorities comes from the pharisee bridge builder.

Engineers are not generally employed by county authorities in letting bridge work. More than likely because their counsel has not been of value, as, not infrequently, county authorities have learned to their cost.

We enjoy the thought that engineering is a science. Our sentiments are: "We labor for economy of time, power and matter." We know that engineers are "skilled in the elements of nature, and making them subservient to the uses of man," and, yet, we have seen repeated examples of engineers in firmly intrenched positions following their emotions as far, quite likely, as any "gullible" public official.

In support of this statement, would call attention to two bridges, shown the society as models, on the society's excursion last September. In one was eccentricity of attachment, and in the other, triangulation was so arranged as to develope ambiguity in action of force through the frame. From a mechanical point of view only, the eccentricity and ambiguity were in no way serious, as the maximum strains could be readily determined, which, undoubtedly, has been done. The extra metal required, due to the eccentricity and ambiguity, in each case, however, would cost more money than the cost of the average highway bridge of the United States.

It is impossible for the engineer, whose experience has been in designing structures for corporations with capital in the millions, to design a bridge for a country community, and not make waste.

It is also impossible for an engineer, without knowlege, to give advice worth money.

The "gullible" commissioner has, in the main, got on to these facts, and does business with the bridge builder.

The highway bridge, as built in the United States, is not ideal, but useful.

That it is as efficient as it can be made for the money invested, I am prepared to maintain.

That there is a class of men in the country, other than the ones designing and building these bridges, who can improve them, will have to be shown by more than mere statement to change the practice.

The highway bridges are built in open competition, and results in a "survival of the fittest."

All have a right to compete. Any engineer, who feels a call to become a bridge builder, finds an open field, and a fair chance. It is only the Pharisee bridge builder who, in his assumption, finds cause for complaint. Competition affects him unpleasantly.

I have an acquaintance with the men, in the United States, who have designed, supervised and built the highway bridges. They are as capable, conscientious, painstaking class of men as can be found in any business. They are as thoroughly posted in the technics of their work, as engineers in any other special line.

True, they have not followed the example of that valuable domestic fowl, the hen, who, when her work is done, loudly calls the attention of the universe to her achievements.

In reviewing the names of the commentators, that is, the gentlemen who have written proposed laws to regulate the building of highway bridges, as well as the gentlemen who have written specifications on the same subject, I fail to find the name or names of any of the men who have designed, supervised or built the highway bridges of the country or any appreciable portion thereof; but I do recognize the names of professors, without practical knowledge or experience in engineering work, railroad engineers, consulting engineers with experience in railroad work and engineers without experience.

Who are the experts in highway bridge building?

If not the men who have designed, supervised and built the structures. Are the railroad and consulting engineers, who in their moments of relaxation, have from their inner consciousness evolved specifications for building highway bridges; or are the gentlemen, who have written proposed laws (the gentlemen who accomplish their engineering works by cackling) the experts?

The business is a small one, in the amount of money used for each crossing. It is a small one, because the local communities, who pay for their work, have but small resources and their ways of life are simple and small.

This phase of the bridge business, I think our committee and commentators have neglected. To make this clear, will cite a case of personal observation.

A congressional township (six miles square) with an assessed valuation of $38,000, had a stream running through it requiring a 200 ft.

bridge; at medium low water the stream could be forded, but with a rise of one foot it was dangerous.

Within ten years preceding the building of the bridge, three people had been drowned (one each, on three separate occasions) in attempting to ford the stream.

With all available funds, and all ability for contracting a debt, the township was able to apply $1,800 for this work. It seemed to be best to build the bridge in one span.

The abutments cost $500. A 200 ft. span was built for $1300, (with profit to the builder) which has served eight years, with every prospect of use for a long term of years in the future.

The thought comes to me: What would the engineers of legislation have done with a case like this. Would they have insisted on this community continuing to take chances on the ford, or have taken themselves out of the way, and allowed a man, with knowledge of how to do it, to build a bridge?

The case cited above is only an exceptional one, in so far as number of persons drowned for the want of a bridge.

Bridges without number are built for our townships, which cost three per cent. of the assessed valuation, when designed for the traffic of the particular locality, only.

If the structures had to be built to the specifications of the commentators, they would cost ten per cent. of the assessed valuation, an amount entirely out of the power of the community to apply to the purpose, compelling them to continue the use of the periodically impassable and dangerous fords, while, now, they are passing over in comfort, unconscious of danger from the stealthy approach of the destructive enemy of highway bridges.

(5) "Road Roller." The *Bogie* of the legislative engineers.

Of its use in country districts, I must confess ignorance, as I do not know of a road roller other than in a city of at least 50,000 inhabitants; however, it has been suggested to me that if road rollers have to be provided for, the most economical way, usually, will be to purchase increased numbers of road rollers, and confine their ravages to stretches of roads between bridges, rather than to build structures, so that the roller would pass over them in a manner quite satisfactory to the gentlemen, who have nothing to do with paying for the bridges. However, if any country district has a road roller, and, also, a bridge, do not understand that the duties of the roller require it to make as frequent and regular trips as the stage coach, or even as frequent as the farmer hauling his produce to market, or that it would come under the head of public travel at all; but if the owner of the roller, occasionally, found it desirable or necessary to take it across his own bridge, he could be trusted to do it in a prudent and careful manner, and, on

these occasions, should the metal be strained ninety per cent. of its elastic limit, it would then be strained for once, to an amount we know occurs on many of our railroad bridges with the passage of each train.

(6) "Pools."

By implication, the committee would have us infer that the engineer has concealed about his person the ability to correct pooling, as well as to avert bridge accidents; what basis they have for this conclusion, they do not make clear.

To expect the counsel of engineers to be of use, we must assume that there is no pooling on works with which engineers have to do; but comment in this connection, is entirely unnecessary.

I cannot but feel it inconsistent of the committee to object to contractors pooling, when arguing for class legislation in support of engineers, which, if it ever amounts to anything, would make a better pool, and a cleaner rake off than anything the highway bridge builder ever aspired to.

Reference is made to sundry writers. One tells us of collusion between contractors and public officials, showing that the writer had familiarized himself very fully with the thoughts of boodle, and had got himself in a dangerous state of mind. I have come to be somewhat suspicions of those who discover only evil in their fellow men.

When a man says that the business of highway bridge building is done by collusion between contractors and the officials, knowing as I do, that the writer is either mistaken or misstates the facts, the conclusion naturally follows: the party is too fresh or the statement is made as a fence.

I must ask the committee to disavow any indorsement of the article as it appears in the Engineering News of March 22nd, 1890. As the report stands, it, by implication, charges the highway bridge builders, as well as public officials, with corruption; not by specific statement of time and place, but by insinuation, which, surely, is beneath the Society to consider.

(7) "To this unsafe condition of affairs there is but one remedy. It is to follow the foreign example: to place the building and maintenance of highway bridges in the hands of expert bridge engineers, and to hold them responsible for the results. In other words, to secure safe bridges for the public, the owners of such structures must be compelled by law to entrust their construction and supervision to competent persons. This is what has been done in European countries, and this is what will have to be done in the United States," is the committee's comment, on the fact that the only appalling highway bridge disasters, within recent years, comes to us from Europe.

I have read and reread with some care the committee's report in connection with what has been done in foreign countries in the way of

bridge legislation. Continental Europe, with strong centralized governments, assumes parental charge of the matter of bridge building.

Great Britain, with a government more like our own, builds highway bridges under the direction of the local authorities, exactly as they are built in the United States. We find, however, that the goverment has been compelled to take charge of the building of the railroad bridges.

In Continental Europe, the government pays for the bridges.

In Great Britain and the United States, the local communities pay for the bridges. In New England and that, which emanates more directly therefrom, this subdivision is carried down to the township.

For the committee to conclude that we are likely to accept state regulation of expenditure of funds of the local community, is not American.

There is little doubt as time goes on,and our country comes to have larger resources, that all classes of work will be more elaborately constructed.

The highway bridges of Europe were, essentially, built of brick and stone, years before the legislative engineer appeared on earth.

I have no doubt when our civilization shall have run another thousand years, that the practice of highway bridge building wili be modified; in what directions and on what lines, I have no disposition to speculate.

The statement further, by implication, says that the highway bridges in the United States are not supervised by competent persons. The same thought is voiced in a number of places in the report.

Have the committee been careless in their statements or shall I (having built thousands of highway bridges, and never having occasion to apologize for a failure either in design or execution) thank God for his mercy (being incompetent) it is only by the interposition of Providence that these works have developed into bridges instead of hetchels.

In general, I think if the committee had shown us where one person had been injured by the failure of a highway bridge, since the Dixon disaster, their case would have been stronger.

Such a tale of woe as the committee tell should have corroborated detail, based on knowledge, and substantiated with specification: instead, we are refreshed with estimated failures, for want of the actual article.

They have given us much in the way of abuse of the highway bridge and the highway bridge builders, but the only attempt to give us any statistics of the insufficiency of the highway bridges, is quoting mere statements of busy bodies who never have informed themselves in the premises.

All statements in connection with insufficiency of highway bridges

and the necessity for legislation, is in connection with superstructures, and those of over 14 ft. to 20 ft. spans, ignoring the short spans, joists, flooring and substructures.

A very large per cent of the accidents that may have occurred to highway bridge superstructures, have been with spans under these lengths or with joists and plank.

Again, and further, there is many times the money directly and indirectly squandered on illy designed substructures for highway bridges, to the amount so squandered on superstructures.

These facts can be verified by the Society without trouble. If our committee had spent but a small part of the energy at home that they did in their investigations in Europe, they would have discovered that the highway bridge floor, on remote occasions, breaks through. That many piers and abutments are either built without proper foundations, or are not carried up above flood line.

To have found a failure in fact, of a span, a truss frame, of recent years, would have been more trouble than to have carried their investigations, not only through Europe, but Asia, Africa, Oceanica and all the Americas, and, yet, the legislative engineer's attack is on the spans, the truss frame. Why?

One of the committee is reported as saying to the Society: "The main point in the construction of highway bridges is to provide that they shall be built by engineers". This, as we well know, is the meat in the "chestnut".

If there were any honest purpose on the part of the legislative engineers to lessen hazard to life and limb or save money to the treasury, what care would there be whether the bridge was built by an engineer or blacksmith, provided the bridges built were good ones.

This class of statements, however, is both useful and instructive, it naturally raises the question whether all engineers are bridge experts. The public know civil engineers, as surveyors. What connection there is between surveying and building structures, is not clear. Bridge experts are known as engineers, but to accept all engineers as bridge experts, exhausts courtesy.

The disposition too often shown by engineers to accept commissions for works with which they are unacquainted, both by education, observation or experience, has much to do with the belittling of the profession.

With twenty-five years experience in highway bridge work, I make the deliberate statement: where engineers have been employed as counsel, said counsel, in a large majority of cases, has been of no use whatever; further, in many cases, it has resulted in much useless cost to the community.

The public would be justified in demanding legislation to protect

them from the engineers. Do not understand me as saying engineers may not be of use.

What I do say is, that most of the engineers, who have been employed, have not been of use.

It might be desirable to determine whether the Society's existence and purpose is to appear as the "third house" of a legislature. If it is, we are on the right track.

If we have confidence that we can move a legislature, let us not be so modest in our demands (which only appear on the face to ask, for engineers, a commission on the money spent for bridge work).

Why not have all the money legislated into the engineers hands?

Bridges cost money.

Money is useful in our business.

With all the appropriations for bridges in our hands, we would place the funds where they would do the most good.

However, if we are an Engineering Society for interchange of thought and experience in engineering works, let us quit trades-union methods.

If the highway bridge is under investigation, let us locate failures, instead of estimating them.

If the knowledge of the highway bridge builder is questioned, show his want in some other way than by insinuations.

If we believe a goodly proportion of public officials are "gullible", modesty would direct us not to proclaim it. Discretion would show us the danger of being measured by the same gauge.

It is only the daily press that has the privilege of charging corruption, without responsibility; we cannot hope to compete.

When we compare the methods and bridges of Europe and the United States, let us get at the conditions, as well as general rules, which surround the works.

Let us make odious, assumption, cant and hypocrisy, when we find them either inside or outside the Society, and give our sympathy to the "gullible" and "incompetent."

My conclusions are:

(1) It is with the railway bridge that the greater risks have been taken, and greater disasters have occurred.

(2) In the "rural regions" stands the highway bridge, to refute the assertion of its insufficiency, as striking an example of the force of mind over matter as anything our civilization has evolved.

(3) The experience with the highway bridge fully justifies taking chances on "unfavorable conditions", when normal conditions are abundantly provided for.

(4) Human nature repeats itself: County authorities and engin-

eers came from the same stock: that there should be any "gullible" is to be regretted.

(5) Let the "road roller" roll.

(6) Our committee's and commentator's knowledge of pooling, boodle and corruption, reflects no credit upon them.

(7) As "this unsafe condition of affairs" is only in the minds of a few individuals, I can only conclude that the brains of said parties are in a condition of unstable equilibrum.

It would be the irony of fate for the state to pass laws regulating building of highway bridges with the attendant state engineer etc., to find a real expert in the position; that is, the "incompetent" highway bridge builder. This would be a "combination of unfavorable conditions", and would be followed by a "collapse" of the engineers of legislation.

SHOP WORK INSPECTION.

By A. L. Johnson, Member Engineers' Club of St. Louis.

[Read February 3, 1892.]

A conscientious man placed in a shop for the first time as an inspector is sure to have trouble, especially if, as is the rule in such cases, he has never seen a shop before. He does not know what he wants in the first place, nor how to get it in the second.

It is certainly however a very good experience for the young man though rather hard on the parties to the contract.

It is not often that such men are employed now, the importance of good inspection being more felt. But they still are occasionally and usually too on large contracts where in particular they do not belong.

The amount of trouble an inspector will have depends on his disposition. Some well-meaning, hard-working men are utter failures because their disposition is such that they can not ask for a thing in such a manner that it leaves no doubt that it must be done and at the same time is not offensive. And as may be readily supposed this is not an easy task. An inspector is by nature everybody's scape goat. He realizes this and it is apt to make an inexperienced man lose heart in the conscientious fullfilment of his duty. There is no general rule for getting along well with the contractor and at the same time getting good work. One of the prime essentials is that an inspector should know his own business and mind it. It is but justice to the bridge companies to say that a man so qualified can get as good work as they can give with very little friction. And in nearly all cases the

man who has the most trouble is the man who knows the least about the business.

Consulting engineers do not usually have enough of this work to train their own men so are seldom able to get men of experience outside the inspection companies.

A word about these companies. They have some advantages and some disadvantages. Their advantages consist: 1st in their ability to do the work very cheaply, and 2nd in being always able to put on the work a man of some experience. They put on new men as helpers to the man experienced and so are able to train their men very cheaply.

Their disadvantages are many. A man working for an inspection company is not apt to do as conscientious work as if he were working directly for the engineer in charge. Because:

1st. The man to whom he is responsible never sees his work. He, at most, only hears of it, which information may be more or less exaggerated and unreliable, or is so regarded, and allowances made therefor.

2nd. He in any case is one step further removed from the consequences of his errors.

3rd. He is apt to be kept at one place all or nearly all of his time.

This has been mentioned by some as one of the advantages of company inspection. The inspector becoming so thoroughly acquainted with the men and methods of the shop. Acquaintance with the methods is very well, but he is apt to become too familiar with the men. He becomes one of them and so loses prestige.

4th. Many companies employ largely practical men,who have no knowledge of the manner of transmission of stress. While this is all right for mill work it will not do for shopwork. In general such men are failures. Each one of them has his own particular hobby which he rides at the expense of every thing else. They are not and do not know how to be even and uniformly rigid in proportion to the importance of the members in question.

Every inspector in order to keep peace in the family has at times to yield certain things to the contractor in exchange for others which he especially desires. He should therefore be able to know what the important things are that he may secure them and allow to the contractor those which may facilitate the work without really injuring its quality. Thus it forms a kind of barter and sale in which each party profits and the spirit of the specifications is filled though the letter may sometimes not be absolutely.

Such occasions as the above often arise when a mistake has been made. For example a piece may have been punched wrong, a section of a girder may have been milled too short, a pin hole in a chord section may have been bored $\frac{1}{4}''$ out of place, etc. This latter admits of no correction but it is sometimes patched up nevertheless. Such and

similar cases are constantly arising on a large piece of work and the inspector is called upon to pass a rapid decided judgment upon them. Often there are several things which might be done and he must decide in a very few minutes which is best for that particular case, taking into account the condition of erection, the time it would take to get new material, etc.

It is safe to say that no bridge has ever yet been built according to the drawings.

For this reason an inspector should have a thorough theoretical knowledge of the communication of stress as also a practical knowledge of details. The order of the different processes of manufacture is as follows:

1. Marking the Material. 2. Rolling. 3. Straightening. 4. Marking and Shearing. 5. Inspecting.	Mill Work.
6. Punching. 7. Straightening. 8. Reaming. 9. Assembling and Reaming again. 10. Riveting. 11. Facing. 12. Boring. 13. Finishing. (Includes hand work necessary to finish piece.) 14. Fitting up. 15. Inspecting. 16. Oiling or Painting. 17. Shipping.	Shop Work.

Sometimes the first process in the shop work would be straightening. If for instance the material has not been straightened at the mill or if in shipping it has been badly handled. Plates especially often need to be straightened before they can be laid off.

The inspection is put toward the end of the list. This does'nt mean, of course, that that is the only place it occurs.

But it is when the final measurements are taken where the definite inspection takes place. There is of course a general inspection through all the processes of manufacture.

In testing steel it is customary to make a blow test on a $\frac{3}{4}''$ round made from each heat and also a finished material test for each heat.

It seems to the writer that the blow test is not essential to the engineer. The contractor would make them for himself, and if from these he finds that the heat is not such as will probably satisfy your requirements he will not risk a considerable sacrifice of material

by rolling it down to your order. You get the test on the material as it is going to be used which ought to be sufficient. To leave it out of the specifications would not, probably, save the contractor any work; but if it is not necessary and as it would save the inspector a good deal of time which he could nearly always employ to better advantage it might as well be done.

Also on eye-bars the final full size test ought to be sufficient with regard to the two kinds of steel now in general use in bridge construction *i. e.*, Bessemer and Open Hearth. The latter has practically been established as being the most reliable. Some astonishing things have happened in steel shapes. As for instance, an I beam falling off a car and breaking square across; channel bars splitting on the tap of an in spectors hammer, plates lying on the floor suddenly cracking with a loud report etc.

Such things have happened with, as far as can be ascertained, no sufficient cause. And in all the cases except one that have come under the writer's notice, these have been made of Bessemer steel. The exception was made of Clapp-Griffiths.

In rolling the material such as angles, Z's, and plate, the smaller sizes are very often rolled from the same sized billet as the larger ones. These of course receive more work and are quite likely to be a little cold rolled. This will show in the physical test a higher elastic limit and ultimate strength with a slightly smaller elongation and reduction. In general the inspector has very little to do with the rolling of the material especially if it is steel. Specifications sometimes contain clauses with regard to the piles for iron, which require his attention. Some engieers also require the inspection of the muck bar.

From the hot bed the material usually goes to the straightening machine. It is then marked off and sheared to length and inspected. With regard to the inspection of the mill material too much emphasis can not be laid upon the necessity of stamping *all* of the accepted material. If not done it will always cause trouble in the shop.

The chief causes for rejection at this point are only such as are mentioned in all specifications and there is no neccessity for any especial remarks upon them.

Steel always rolls much nicer material than iron which is one reason why it is cheaper, the percentage of waste being so much less.

The first process in the shop is straightening when necessary, marking off, and punching. For this is used the simple punch and the rack and multiple punches. These latter do a great deal of work but it is not usually as true as the gauged single punch work. Complimentary angles are clamped together and racked through. The angles have more or less spring in them, the punching puts in still more so that the gauge does not come out a constant throughout the

piece. After punching, the material should be again straightened, since the punching will spring it. This is a very important item but one which in some places is totally neglected. It is very difficult to rivet crooked work. The angles and plates do not fit together well and in the ordinary process of rapid riveting the rivet will be sufficiently hot after the pressure is removed to allow the spring between the plates and angles to distort or draw the rivet some. When the next rivet goes in it draws the material up again and this leaves the first rivet loose.

The writer has had as high as 20% of the rivets in a girder to cut out, all due he firmly believes to this one thing.

Of course the finished work in unstraightened material never looks as well as it ought.

The processes next in order after punching are reaming, assembling, and reaming again.

After being punched the material is reamed to a diameter $^1/_{16}''$ larger than the diameter of the rivet. When assembled the holes in the angles will not correspond with the holes in the plate exactly, due to the stretching of the angles in punching and accidental causes. The amount of this elongation varies with different weights and sizes of angles from about $\frac{1}{8}''$ to $\frac{1}{4}''$ in 20 ft.

Now in a 30′ girder the holes near the ends may not fit by $^3/_{16}''$ one will suppose. Then the reamer is put through and takes off not more than $^1/_{16}''$ from the angles and the remaining $^2/_{16}''$ from the web. This leaves $\frac{1}{8}''$ at the web into which the rivet must back up in order to fill the hole and be able to transmit stress. It takes a good machine to do this well. Very often it would not be done. For this reason the writer is in favor of punching material $\frac{1}{8}''$ less than diameter of rivet and only one reaming, that being done after the pieces are assembled. The probabilities of getting a smooth even hole of true size all through would then be much increased. It may of course be objected to this method that you would not get all of the injured metal around the hole removed. That is true, but in the first place it has not been satisfactorily established that the hole, in soft steel, has been materially injured in punching, and in the second it would be better to have this vacant space filled with anything than with nothing at all.

Of course the inspector has simply to follow his specifications and this will nearly always mean two reamings.

With regard to the riveting by machine, there ought not, usually to be much trouble. Ordinarily an inspector does not have to inspect all machine rivets.

In machine countersunk riveting we often find a great many loose rivets, after being chipped. The reason is probably this: The rivet in order not to be too short has been made a trifle long and this excess

material spreads out under the die and overlaps the hole. This edge being thin becomes cold and hard very quickly and then no amount of pressure will make it any tighter in the hole. The rivet will appear tight until chipped when often it is very loose.

Up to a length of three inches, and with proper care and with experienced men, better countersunk rivets can be driven by hand than by machine. In hand riveting spring dollies should be used where possible especially for heavy pieces. The ordinary simple dolly for light work will give good results.

In marking rivets to be cut out the inspector should use white lead, and also either a center punch or the stamping end of his hammer to mark the head of the rivet itself.

The inspector sometimes has trouble with hand rivets in light work. Often $\frac{7}{8}''$ steel rivets are used in riveting $\frac{3}{8}''$ and even $\frac{5}{16}''$ metal. This should not be done. It is often hard to buck up well where such cases occur and loose rivets are therefore common. In taking them out the plates sometimes split before the head will shear. Then if the holes do not match well, the plates will be badly bent in backing the rivet out.

Material lighter than $\frac{3}{8}''$ does not work well in the shop. Also light weights in large sizes do not work up as well as heavy weights in small sizes. Some portions of a structure should always be fitted.

Whenever joints or splices occur which are to be riveted up in the field they should first be fitted up in the shop. For instance, three panels of chord section (two joints) should be fitted up. Portal bracing, and stiff transverse bracing where it occurs.

With regard to the other processes of manufacture it is probably unnecessary to say anything. The writer wishes however to say some things on the general supervision of the work and give his idea of a good arrangement of inspection on a large contract.

Suppose a contract for 5,000 or 10,000 tons of material has been let by the R. R. to a certain company for construction. They of course are apt to obtain their material from several different mills. If the parties letting the contract think they can afford it, their best plan is to employ their own inspectors.

Such a contract as the above would require probably three inspectors. One of these would be employed on mill work exclusively and would reside at the point from which he could cover the work located at a distance from the bridge shop. Since delays so often occur in the mill work sometimes it might be better to let this work out to a company.

The other two would reside at the place where the work is being manufactured, of these, one should be chief inspector to whom the others should report. The other would assist in inspecting the remaining mill work, and when not so employed would be at work in the shop, keeping up invoice reports, checking weights of same, keeping track

of material or daily progress report, making tests, and various other things.

Now if there is a penalty in connection with the work as there usually is, another object of the inspection is to be able to testify as to the cause and character of any delay in the prosecution of the work. To keep track of the material in such a way that this can be done is not a simple matter. On such a contract as has been named it would require the inspector to know, at any time, the exact condition of from 12,000 to 24,000 pieces of material.

It is one of the objects of this paper, however, to show that it is by no means an impossible thing, nor such an imposing task as it would seem at first. It is however too much work for one man to do this and all the other inspection too, especially as an assistant, such a man as the one mentioned above, could be obtained for from $50 to $60 per month, who could also do the other work mentioned, some of which would otherwise have to be done in the Engineer's office at an expense probably of $100.00 per month.

Of these 12,000 to 24,000 pieces mentioned above not all are changing their condition each day. Probably half of them are. Then too they go in groups so that we can greatly reduce the number. As I have said it would be one of the duties of the asistant inspector to keep this record.

To do this he would require a day book ruled as below:—

Left Hand Page. Right Hand Page.

General Remarks.	Punched.	Reamed.	Bolted.	Riveted.	Milled.	Bored.	Turned.

In these columns he each day enters the designation of the piece which has received that particular treatment. It will not always be possible for him to get these independently of the contractor, but that is not necessary. If he goes about it in the right way the contractor will allow him access to the daily reports of the shop which of necessity are as correct as may be. From there he can readily get the last five columns and enter them directly into his day book. Punching and reaming are more difficult to get. But these also in most shops

he can get from their own records. They will give however the record for the component pieces and not for the whole member, very probably. In this case he cannot use the day book at first but must take the shop list on which all of the members with their component pieces are given, and a copy of which he can get.

No. of Draw.	Name Piece.	Length Over All.	Length Bet. Pin Centers.	Size Pin Hole.		Size Web or Bar.	Size Chord L's.		Thick Pin Bear.	Clearance.		Cover Plts.	Splice Plts.	Remarks.
				N.	S.		Top.	Bott.		In.	Out.			

The tables for top chords and posts are not very different from above.

On these sheets using red ink entirely, he rules two columns, one for punching and one for reaming and then enters up these records for each of the essential component pieces with date. Then when these have all been treated for that member he enters it in his day-book for the day on which the last really necessary piece of the member was finished.

For keeping track of the mill material he checks off on the mill order, a copy of which he has, the pieces from invoices as they come in, entering date of receipt of car.

Thus the assistant has a record of every piece from the time it left the mill until ready for finishing and inspecting.

The rest is obtained by the Chief Inspector himself, as is also the progress of the work at the mill from the mill inspector who reports to him every week and oftener when need be as also to the Chief Engineer if he desires it.

In the meantime the Chief Inspector has all he can attend to. There may be as high as 200 or 300 drawings of details and at one time the shop may be at work on as many as 30 or 40 of these. It is impossible to carry around such a load of drawings for the inspection. The writer has used the following plan:

Tables were prepared for all the classes of members with a column for each one of the important descriptive features of such members. The drawings were then carefully gone over and these columns filled

out. The table for bottom chords is given on previous page.

For the diagonals, if they are simply eye bars, a very simple table tells all the story. If combination or riveted members, of course a more elaborate table will be required, but easily made out to suit the case.

The Floor Beam table would be as follows:—

No. of Draw.	Name Piece.	Leng'h	Size Chord L's.		Size End Stiff.	No. Riv in end Con'ec	Size Web.	Remarks.
			Top.	Bott.				

In case the floor beams have hangers or a connection directly to the pin, slightly different tables would be required. There are a few other measurements to be checked, some of which need not be taken all the time, the others are practically a constant and easily learned so that columns for these are not necessary.

The table for stringers will be similar to that for floor beams except that, if it is elevated or viaduct work, a column for bevel will also be required, thus:—v, being grade bevel; h, curve bevel; and f and e being fixed and expansion ends respectively.

Bevel.			
v		h	
f	e	f	e

The other things such as pins, rollers, pedestals, bracing rods, lateral plates, etc., are all easily tabulated. Often it is not necessary nor even advisable to do this, however. They can probably be more easily inspected from the drawings or shop list.

But this advantage of tabulation should be taken into consideration. It enables you to have always with you at no inconvenience to yourself, a complete record of *all* the pieces.

There is no *trusting to memory in this system.* It is absolutely rigid. If, in passing through the shop at any time, you happen to notice something wrong, a bad angle, for example, taken from stock without inspection, you take out your book, make a note of same opposite the piece in which it belongs, mark the angle with your hammer and then notify the foreman of that department. Now that member may be put away and not come up for inspection for several weeks, depending

upon circumstances. You probably in the meantime have forgotten all about it. But when it does come up, you open your book at that point preparatory to inspecting it and then you find a note. Of course if the defect was still as glaring as at first you would discover it anyhow. But it probably is'nt. You now look for your hammer marks and very likely find them, when the angle has to be cut off and replaced.

In inspecting a finished piece, you first try the rivets, then make the measurements by your book. If the piece is found wanting in any particular you make a note in your book in column of remarks, putting date above, and mark the piece with white lead or soap stone, the latter, preferably. When the piece is accepted some convenient sign indicating same is put in the book, with date also, and the piece is stamped.

When he receives invoices of shipments the first thing the inspector does is to check off these pieces from the invoices into his book. These of course should all have been accepted and should be so indicated in the book.

Preparing these tables may be some work. But if the inspector does'nt have them he has to familiarize himself with drawings in order to be able to inspect from them. While doing that he might as well do it systematically and prepare the tables, at no great additional outlay of time. They pay for themselves many times over. It relieves him of anxiety. He feels that nothing of any consequence can be done without his full knowledge and consent.

Of course on a small contract, with a few drawings of details such an elaborate system is neither necessary nor desirable. But on such a one as has been mentioned it is probably the most absolutely reliable of any. Measurements may be taken with a steel tape after being compared with the company's standard the correction for every ten feet being learned. It is the most accurate method of any, since being so thin, it readily assumes the temperature of the piece and then only the difference of the two coefficients of expansion remains, which of course is small.

The inspector should, if necessary, divide his inspection up so as to inconvenience the contractor as little as possible. It is not always advisable to leave the inspection until the piece is entirely finished. By the system mentioned above this division of the work is rendered much less troublesome and equally reliable.

There is a difference of opinion amongst inspectors, also amongst engineers, as to whether final exact measurements are necessary, especially where the contractor puts up his own work. It may not be necessary but it is advisable. Nothing ought to need to be altered in the field. To attain this end there can not be too much inspection in the shop. Besides it relieves the inspector's anxiety wonderfully.

The inspection of erection is just as important an item as the inspection of shop work but as it is outside the limits of this paper nothing is said of it.

AN INCLINED CABLE RAILWAY FOR TRANSFERRING FREIGHT CARS BETWEEN THE UPPER AND LOWER YARDS OF THE WESTERN CABLE RAILWAY CO., ST. LOUIS, MO.

By Edw. Flad, Member, Engineers' Club of St. Louis.

[Read January 20, 1892.]

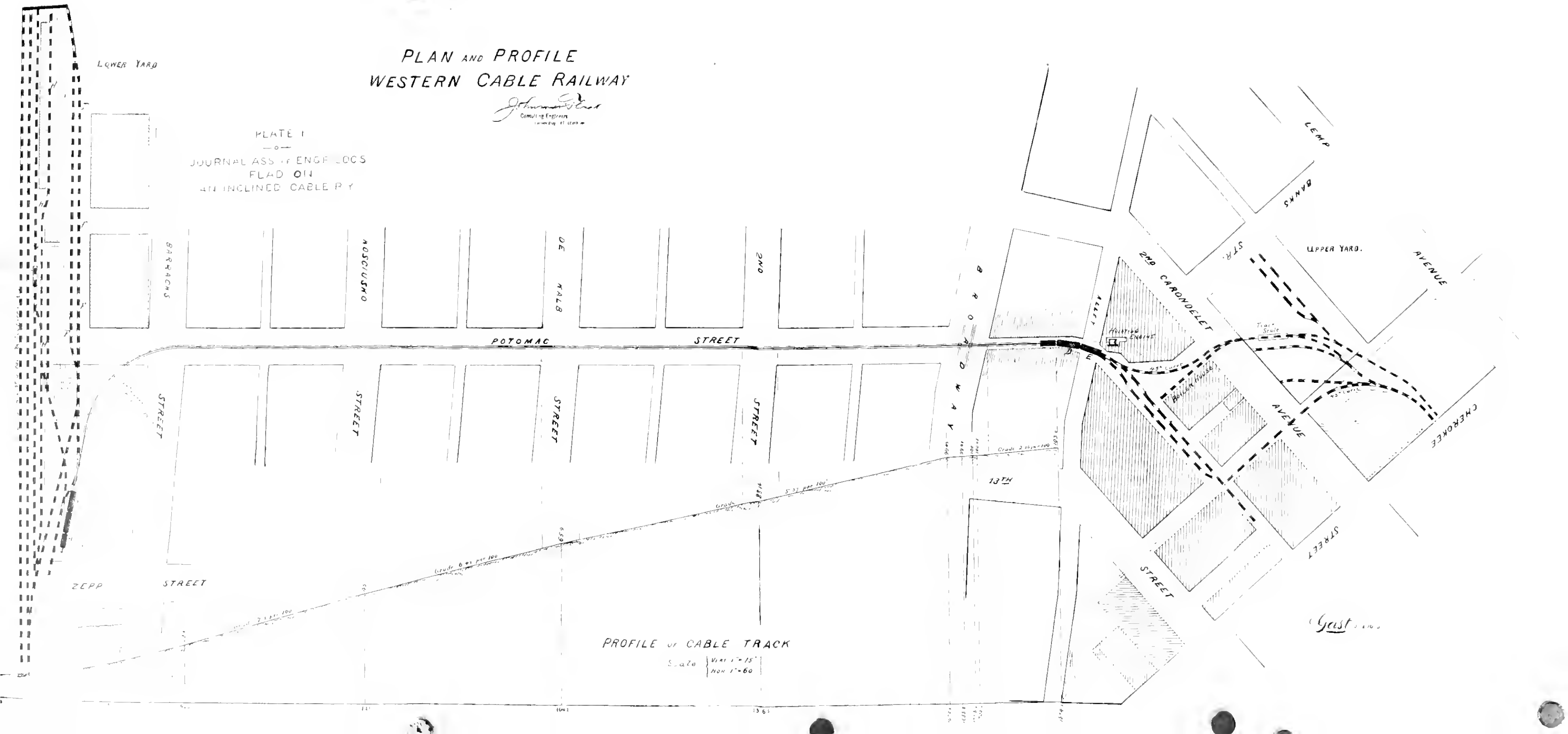
The Western Brewery of St. Louis, more commonly known as Lemp's Brewery, is located at a distance of about 2,000 feet from the tracks of the Iron Mountain Railroad, and at an elevation above the tracks of 95 feet. There is a continuous ascent from the Iron Mountain tracks to the brewery, the steepest grade along Potomac street which connects the two being $7^2/_{10}$ per cent.

Formerly all freight, whether supplies for the brewery or beer shipped therefrom, was loaded and unloaded in the lower yard established next to the Iron Mountain tracks, being transferred by means of wagons between the yard and the brewery. The expense, delay, and annoyance incident to the hauling, up and down so steep a grade, of the large amount of freight, which required from thirty-five to forty two-horse wagons, rendered it desirable to adopt some other method, and finally led to the construction of a cable road by means of which the regular freight cars are transferred between the lower yard and an upper yard which was established on a level with the brewery buildings.

The original preliminary plans were made a number of years ago by Col. Henry Flad with the writer as assistant. At that time a wooden construction was proposed for the cable track. In June, 1890, the Western Cable Railway Company entered into contract with Johnson & Flad to furnish detailed plans and specifications and superintend the construction of the road, and Col. Henry Flad was retained as Consulting Engineer. Work was begun immediately upon the plans, contracts for the material were let, and the construction was prosecuted as diligently as possible. The road was completed and put in operation in June, 1891, and since then it has been in constant use.

General Description.

A hoisting engine, with a drum of a capacity sufficient to hold the whole length of the cable, is placed at the upper end of the incline. The upper end of the cable is fastened to the drum and from there the cable passes underground, in a conduit placed between the rails, to the grip car to which the lower end of the cable is fastened permanently.


PLAN AND PROFILE
WESTERN CABLE RAILWAY
PLATE I
JOURNAL ASS. OF ENGR. SOCS.
FLAD ON
AN INCLINED CABLE R.Y.
LOWER YARD
BARRACKS
KOSCIUSKO
DE KALB
2ND
BROADWAY
POTOMAC
STREET
STREET
STREET
STREET
STREET
ZEPP
STREET
13TH
2ND CARONDELET
AVENUE
ALLEY
Hoisting Engine
Boiler House
LEMP
BANKS
STR.
UPPER YARD.
AVENUE
CHEROKEE
STREET
STREET
PROFILE OF CABLE TRACK
Scale Vert. 1" = 15' Hor. 1" = 60'
Geist

The conduit is provided with a slot through which the grip plate from the car passes.

To take the cars up hill, the grip car is placed at the lower end of the road, (Plate 1,) at *A*., the freight cars are placed in front, *B*. and *C*., and the train is started up the hill with the grip car at the lower end of the train. The cars are pushed up to the position *D*. *E*., being on a level with the tracks in the upper yard. From this point they are transferred by means of a light locomotive which is employed to do the switching in the upper yard.

In going down hill the train runs by gravity, pulling the rope along. In either case the grip car is at the lower end of the train so that the safety of the train is not dependent upon the couplings. Two loaded or three empty cars are transferred at each trip.

Upper and Lower Yards.

In the lower yard the cars which are to be taken up the hill are placed on the tracks *F*. These tracks are laid on a grade of $\frac{1}{10}$ ft. per 100 feet towards the cable track, so as to facilitate tne running of the cars in that direction. It was originally intended to lay the tracks *H*. with the same grade in the other direction, as these tracks are used for cars that have been brought down from the brewery and are ready for shipment. By so arranging the grades however, the yard would have been rendered less accessible for wagons, so these tracks were laid level instead.

In the upper yard the tracks are all level. The sharpest curve is a 45 degree curve (130.6 ft. radius). This curve occurs in both yards, but more frequently in the upper yard. The outer rail is not elevated on the curves and the gauge is increased only $\frac{1}{2}$ inch. All the switching in the lower yard is done by means of horses. One team of horses readily hauls two loaded cars at a time. Two teams are employed to do the switching in the lower yard. In the upper yard, for a considerable time after the road was put in operation, the switching was done by means of horses, but as before stated a light locomotive is now employed for the purpose.

Grades.

The cable road is built on a straight line with the exception of one curve at the lower end. This is a 35 degree curve (radius 166.3 ft). The profile of the line is shown on Plate I. The lower end has a grade of 2 feet per 100 feet, up to the beginning of the curve. In passing around the curve the grade is increased gradually. At the upper end of the curve the grade is seven and two-tenths per cent. for a distance of about 300 feet. From there it changes to 6.48 per cent. and then to 5.37 per cent. up to Broadway. At Broadway where the line crosses the tracks ofthe Broadway cable road, the line is level and from

there it again changes to a 2.26 per cent. grade up to the upper end of the road.

Control of Train.

The movements of the train are controlled entirely by the engineer at the hoisting engine. Electric signals are established between the hoisting engine and the grip car so that the conductor on the grip car can at any time signal to stop, start, or to go up or down. The electric wires for signalling, as well as for the operation of the safety stop device, to be described hereafter, are placed in the center of the steel cable, the ordinary hemp core being replaced by an electric core.

The grip car is provided with attachments which enable the conductor to stop the train at any time while going down hill. It is also arranged so that in case the cable breaks the safety device is applied through the breaking of an electric current passing in one of the wires in the core.

Switch Track Construction.

In the yards a 63 lb. steel rail is used. The tracks are all laid on macadam ballast extending to a depth of 9 inches below the cross-tie. Where the roadway is paved, in the upper yard, the rails are laid on longitudinal stringers, granite blocks are used for paving, and sewer inlets are placed in the center of the track. In place of the ordinary groove for the wheel flanges the whole pavement between the rails is depressed, making a neat construction and one that is readily kept clean.

Cable Track.

The cable track is formed by 85 lb. steel rails 5 inches high, resting upon cast iron yokes placed 3½ ft. between centers. The slot rail is a Z rail weighing 53 lb. per yard. The conduit is formed of concrete which fills up the space between the yokes and extends to a depth of 10 inches below the bearing of the yoke under the rail. In laying the concrete, wooden forms were used similiar to those used in the ordinary cable road construction. The conduit is 9 inches wide and 20 inches deep, measured from the top of the slot rail. The concrete is composed of two parts of Portland cement, five parts of river sand and ten parts of broken stone.

The Yokes:—(Plate II) weigh about 500 lbs. each. and are designed so as to give ample bearing surface for the heavy loads which are carried; the construction being different from the ordinary yokes especially in the large bearing provided directly under the rail. The rail joints are always made at the yokes.

The Vertical Sheaves:—(Plate II) which are placed generally, at intervals of 31½ ft., are of cast iron with a chilled groove for the rope. The sheave is five inches in diameter and has a steel shaft with bearings of babbitt metal. The sheave moves in a cast iron frame resting on

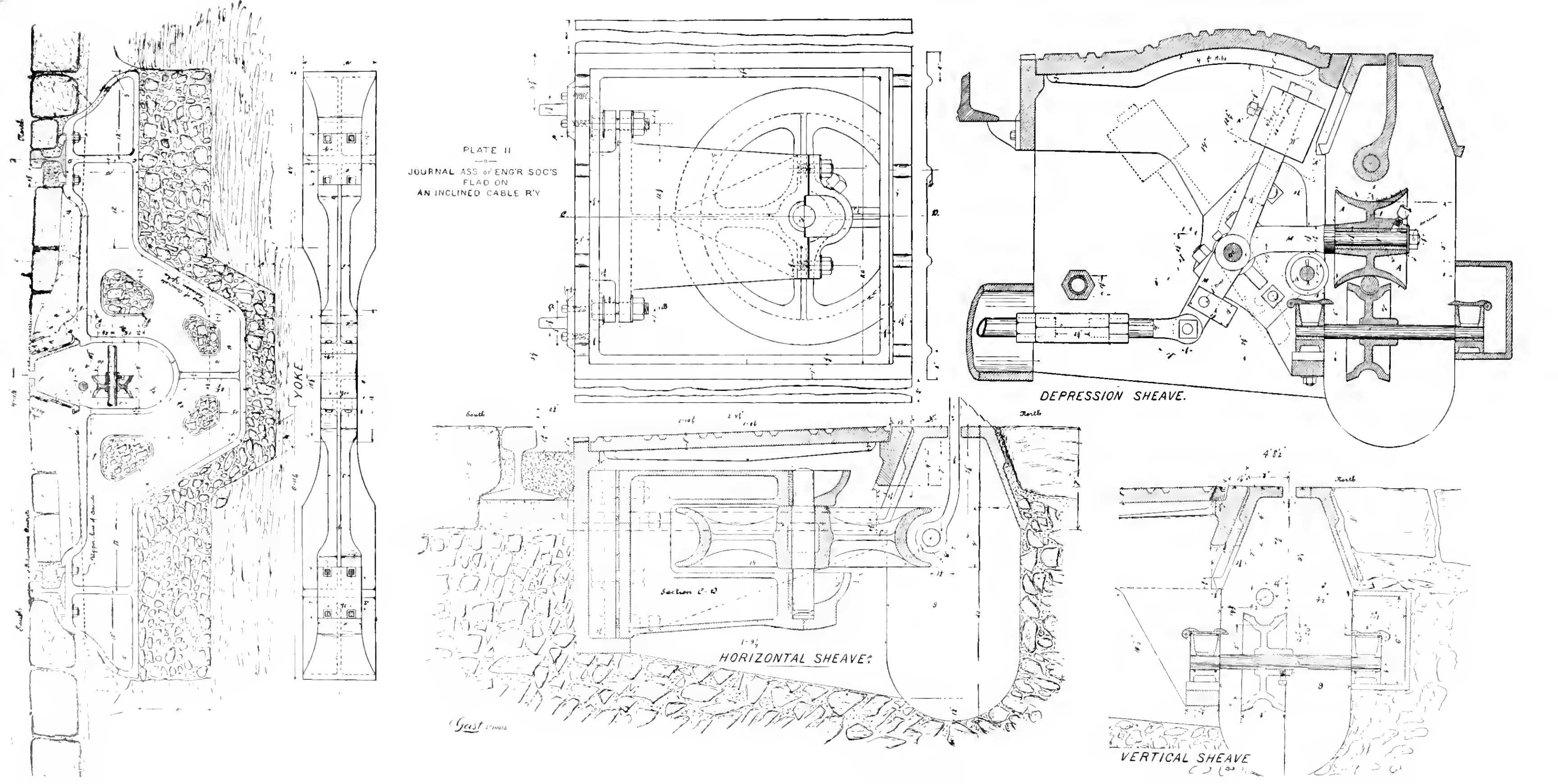


PLATE II

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FLAD ON

AN INCLINED CABLE R'Y

one side on a cross-bar of the man-hole frame, and on the other side in a cast iron wall box. The original sheaves were but three inches wide, but they have all been replaced by sheaves of a width of 7½ inches. The frame and sheave are removed as a whole.

The Horizontal Sheaves:—(Plate II) placed at the lower end of the line are 3½ feet apart. The sheave is of cast iron fourteen inches in diameter and has a four inch face. The shaft is of steel and rests upon a chilled cast iron button. The bearings are of babbit metal. The frame and sheave are introduced as a whole, and when in position the frame is bolted to flanges provided in the man-hole casting. A sheet iron cover, not shown in the drawing, protects the upper bearing.

In laying the curved track the T rail was first bent cold to the required radius. An attempt was made to bend the slot rail, but in bending the rail cold the cross-section of the rail was altered, so it was decided to bolt the slot rail to the yokes and spring it into position. This method proved successful, the slot rail being prevented by the jaw of the yoke from changing its shape in cross-section any considerable amount.

At the *Broadway Crossing* the conduit is made deeper to provide for the operation of the Broadway cable road which crosses the line of the Western Cable Railway at this point. The cables of the Broadway line are depressed at the crossing, passing under the cable of the Western Cable Railway. The Broadway gripman drops the rope and the car passes over the crossing by its momentum. On account of the change of grade it was necessary to introduce a depression sheave to keep the cable of the Western Cable Railway sufficiently depressed to allow the grips of the Broadway cars to pass over the cable.

The Depression Sheave A. (Plate II) is placed upon a bell-crank *M.* pivoted at *O.* It is operated by means of a lever which is placed in the gate house in which the air pumps which operate the crossing gates are also located. Whenever the car passes the depression sheave, the sheave is raised to the position shown by the dotted line *A′*. The rope is depressed 8¼ inches below its position in the grip plate. In case the attendants fail to raise the sheave at the required time the increased upward stress on the sheave causes the breaking of the pawl which holds the lever, this being made the weak point, and then the sheave rides up on the rope and over the grip plate without further damage. This accident occurred during the early operation of the road, with the results anticipated, causing no more damage then the breaking of the pawl which was quickly repaired.

HOISTING ENGINE.

The drum, 12 ft. diameter, 6 ft. face (Plate V) is connected to the large gear wheel by means of a friction clutch, and has a band friction brake, consisting of a wronght iron band lined with basswood blocks

10″ wide and 3″ thick, operated both by a hand lever and by a small steam cylinder, which latter is used only in case of emergency. An intermediate gear connects back to the pinion on the engine shaft. The engine has two cylinders 14 inches diameter × 15 inches stroke. The main drum shaft is 10 inches in diameter with bearings 9″ × 16″. The main gear wheel is 15′-1″ in diameter, has a 10″ face and 144 teeth with 4 inch pitch. The cylinders have slide valves operated by link motion. One hundred and fifty revolutions of the engine gives a rope speed of five feet per second, which is the ordinary speed of operation of the road.

All of the levers for operating the drum and engine are placed upon an elevated platform from which the operator has a view of the greater part of the line. The hoisting engine rests upon a foundation of brick laid in Portland Cement mortar.

GRIP CAR.

The grip car (Plate III) is fastened permanently to one end of the cable, the other end being fastened to the hoisting drum. The grip plate is of steel $^5/_8$ inch thick, and at its lower end is 9 inches wide. The lower end of the grip plate is forged into a bulb which is bored conically for the insertion of the cable. The electric core passes through the hollow steel wedge, and from there up into the car. The strands of the cable are wedged into the bulb by means of the hollow steel wedge. Before this mode of attachment of the cable was adopted an experiment was made upon a short piece of cable held in the manner described, and it was found that the grip developed the full strength of the cable without showing any signs of weakness, the cable breaking under a tension of 83,000 lbs. One end of the test piece was looped around an eye and spliced, and one of the strands in the splice broke first. If both ends of the test piece had been held in the form of grip described a higher breaking load would probably have been obtained. The cable has six strands of 19 steel wires each and its breaking load as given by the manufacturer, being figured upon the combined ultimate strength of the individual wires is 123,000 lbs. The ultimate strength of the wire used is 190,000 lbs. per sq. in.

The maximum stress to which the cable is subjected in the operation of the road is about 15,000 lbs. not taking into account the increased stress that may occur, due to a sudden application of the load.

The grip plate is hinged to the longitudinal car timbers, so as to allow for lateral motion.

SAFETY APPLIANCE.

The design of the safety stop device is as follows:—

A trolley (Plate IV) runs under the car on the slot rails and is attached to the car by means of two chains passing over the sheaves *S* and *S′* (Plate III). The other ends of the chains are attached to the cross-head

PLATE III

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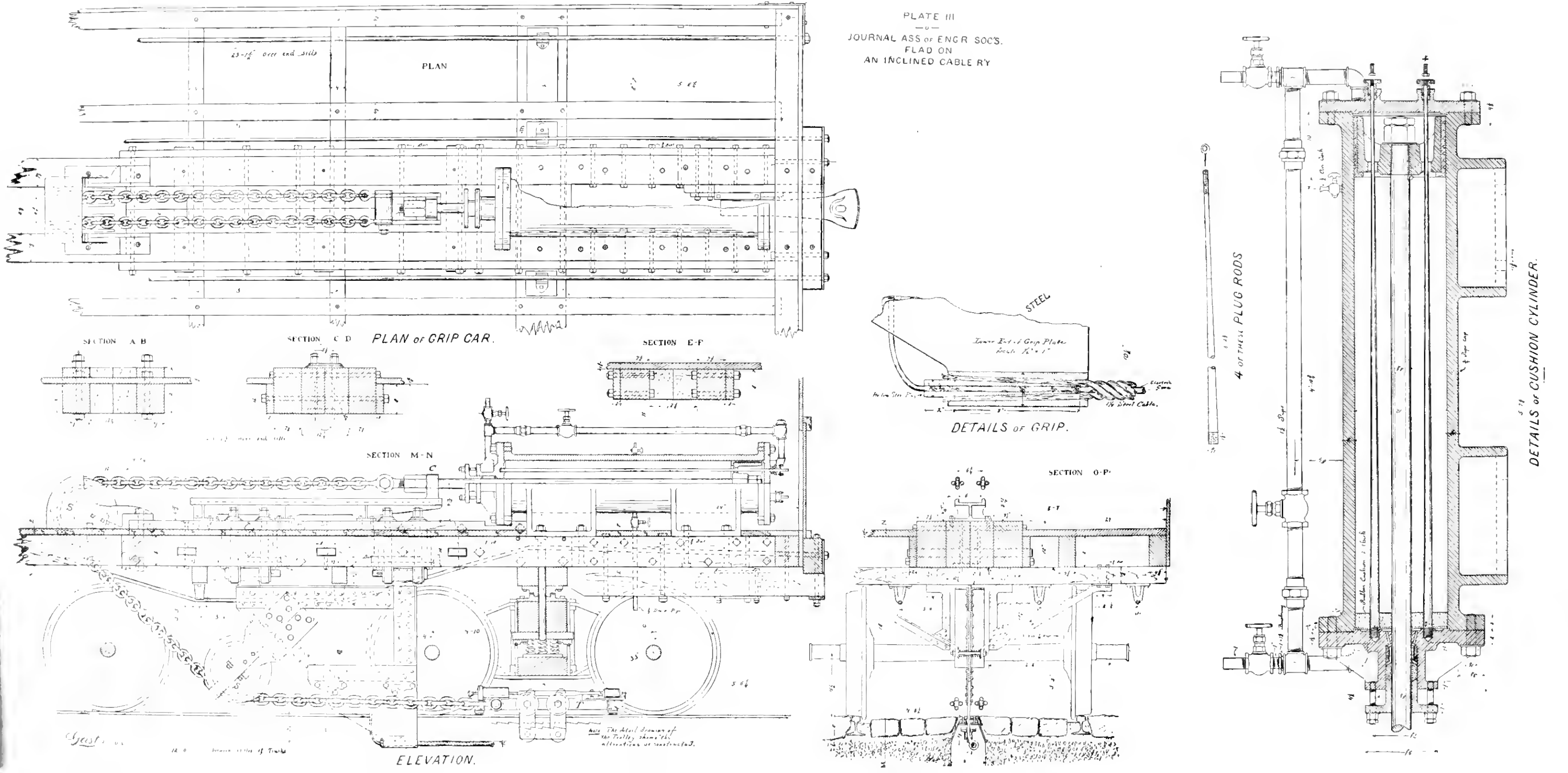
FLAD ON
AN INCLINED CABLE R'Y



C. The piston operates in a cylinder filled with glycerine and water, the cylinder being bolted to the car body. A cast iron rack is riveted to the under side of the slot rail and the trolley carries a rack of forged steel suspended below the slot rail by two straps which pass through the slot. The spring on the trolley tends to throw the trolley rack up into the position shown by the dotted lines, in which position it engages with the rack on the slot rail. A latch is inserted to prevent the spring from coming into action. If for any reason it is desired to stop the train suddenly, while going down hill, the conductor pulls a handle in the car which releases the latch on the trolley and allows the two racks to engage. The trolley then comes to a sudden stop, but the train travels on until the energy in the moving load is taken up in the cylinder, forming a cushion with a total motion of 4′ –9″.

The piston is provided with four holes through which tapered plug rods pass, and when the piston moves, the valve on the by-pass pipe being closed, the water is forced through these holes in the piston. As the velocity of the piston decreases, the train being brought to a gradual stop, the openings through which the water is forced also decrease in size, being designed so as to give a constant velocity to the water passing through the openings. A constant velocity here, means a constant pressure on the piston tending to retard it, and hence a constant force tending to stop the train.

The parts are so designed that with a load of 180,000 lbs. travelling down a $7^2{}_{10}$ per cent. grade at the rate of 5 feet per second, the train will be stopped in a distance of 4 feet, with a uniform tension on the chain of about 30,000 lbs,

The calculations are as follows:—

Weight of 2 cars @ 80,000 lbs.	160000 lbs.
Weight of Grip Car.	20000 "
Total load	180000 "

A load of 180,000 lbs. moving down a grade of $7^2/_{10}$ ft. per 100 ft. at the rate of 5 ft. per sec., is to be stopped in a distance of 4 ft. by a uniformly resisting force.

1st. What must the resisting force be?

2nd:—What must be the size of the openings in the piston so that the hydraulic head due to the velocity and friction of the water through the holes will be sufficient to bring the required resisting force upon the piston?

The energy of the moving load is

$$\frac{W\ v^2}{2\ g} = \frac{180,000 \times 5 \times 5}{64.4} = 70,000 \text{ ft. lbs.}$$

While moving 4 ft. down the 7.2 per cent. grade an additional amount of energy will be developed.

Let Θ = the angle of the grade

$W \sin \Theta \times 4 = 180{,}000 \times 0.072 \times 4 = 51{,}840$ ft. lbs.

Making a total of 121,840 ft. lbs. to be overcome in a distance of 4 ft., which will require a uniform resisting force equal to 30,460 lbs.

The piston has a diameter of 12 inches, and after making proper allowance for the piston rod and for the holes in the piston, we have an area of 103 square inches. A pressure of 295 lbs. per sq. inch, equal to a head of water of 678 ft., will give the required 30,460 lbs.

In order to obtain a pressure of 678 ft., the velocity of the water through the holes in the piston must be

$$v^1 = 8.025\ c \sqrt{h}$$

h = head in feet = 678

c = co-efficient = 0.7

v^1 = velocity, ft. per sec.

$$v^1 = 8.025 \times 0.7 \times \sqrt{678} = 146 \text{ ft. per sec.}$$

Let v = velocity of piston = velocity of train,

" A = area of piston,

" A^1 = area of openings in piston,

$$A^1 v^1 = A\ v \qquad\qquad A^1 = \frac{A\ v}{v^1}$$

The train is being retarded by a uniform resistance F, equal to the difference between the pull on the chains, and the component, along the line of the grade, of the weight of the train, or

$$F = 30{,}460 - 12{,}960 = 17{,}500 \text{ lbs.}$$

Let a = negative acceleration due to the force F.

If a body W be acted on by an unbalanced force F, the change of velocity in the direction of F, produced in a second will be

$$a = \frac{F\ g}{W} = \frac{-17{,}500 \times 32.2}{180{,}000} = -3.13 \text{ ft. per sec.}$$

The velocity of the train at any point at distance d, from the point at which the resisting force is first applied is found from the equation

$$d = \frac{v^2 - v_0^2}{2a} \qquad\qquad v = \sqrt{v_0^2 + 2\ a\ d}$$

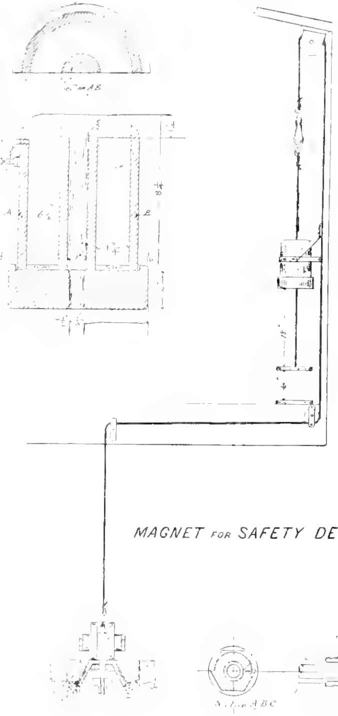
Substituting this values of v in a former equation, we have

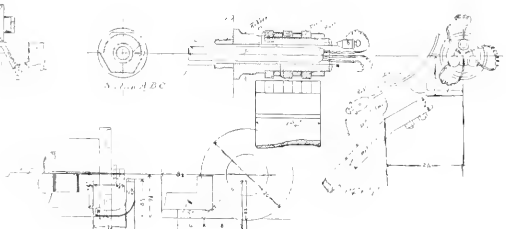
$$A^1 = \frac{A \sqrt{v_0^2 + 2\ a\ d}}{v^1}$$

$$A^1 = \frac{103 \sqrt{25 + 2\,(-3.13)\ d}}{146} = 0.705 \sqrt{25 - 6.26\ d}$$

By substituting values for d we find the required areas of opening at different points of the stroke.

d = 0 ft.	A^1 = 3.53 sq. in.
d = 1 "	A^1 = 3.05 " "
d = 2 "	A^1 = 2.50 " "





MAGNET FOR SAFETY DEVICE.

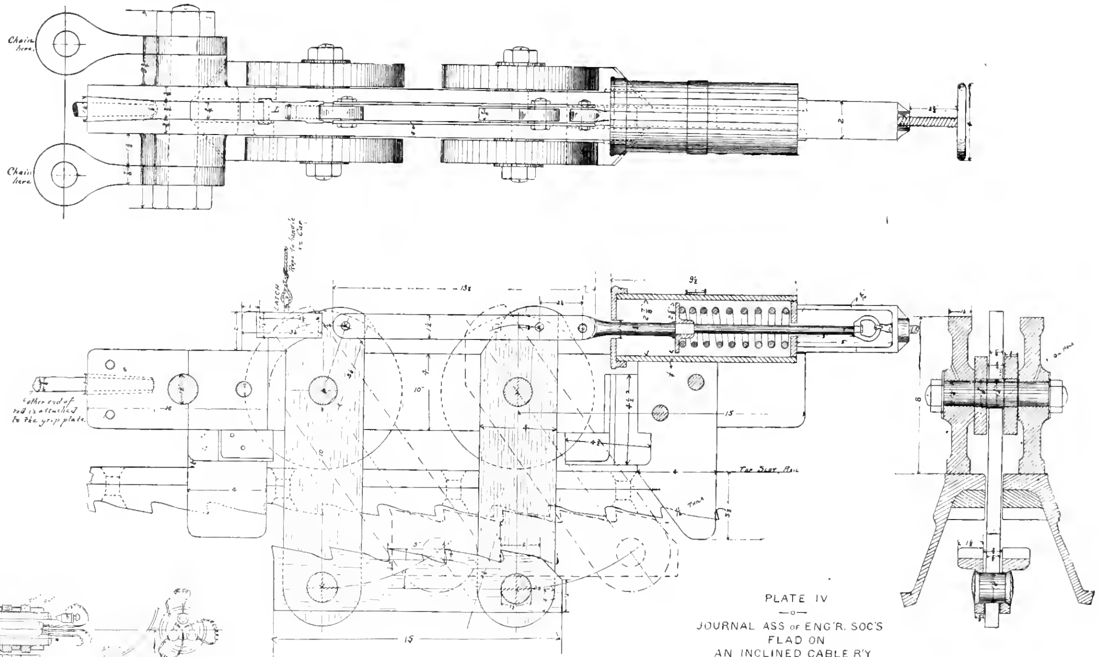


PLATE IV

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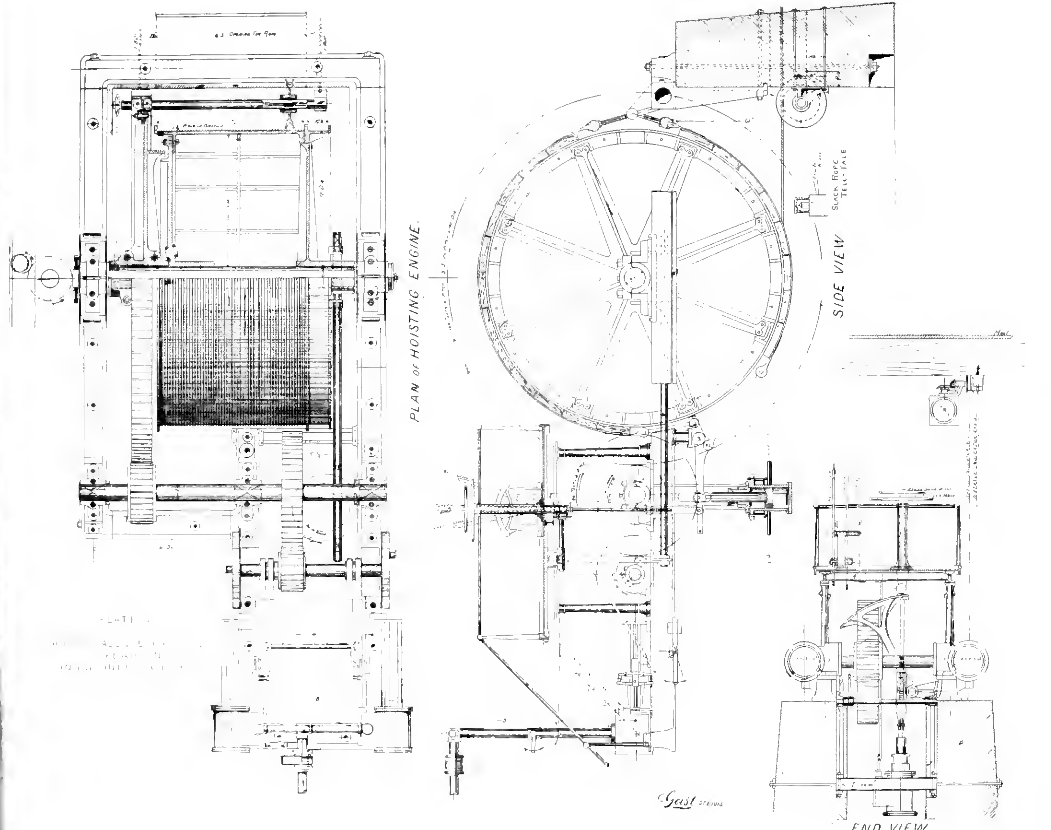
FLAD ON

AN INCLINED CABLE R'Y

TROLLEY FOR SAFETY DEVICE.

Gast St Louis



PLAN OF HOISTING ENGINE.
SIDE VIEW
SLACK ROPE TELL-TALE
END VIEW.
Gast St. Louis

$d = 3$ " $A^1 = 1.78$ " "
$d = 4$ " $A^1 = 0.00$ " "

These varying areas are obtained by means of the conical plug rods which pass through the holes in the cylinder.

Shortly after the completion of the road this safety appliance was tested in the following manner: The grip car with two loaded beer cars weighing in all about 170,000 lbs. were moving down on the $5^{57}/_{100}$ per cent. grade at the usual speed (about 5 feet per second) when the latch was pulled and the train came to a stop within the 4¾ feet without any perceptible shock and without any damage whatever. They have used the safety appliance five or six times since the road was put in operation thereby preventing serious accidents. At one time the train was moving up the hill when the friction clutch on the drum broke and the train began to back down hill. The engineer at the hoisting engine saw that the drum was reversing rapidly, but was at a loss to know the cause, or what action to take.

The conductor on the grip car realizing that something had happened, pulled the safety device handle and stopped the train, thereby averting what might have proved a fatal accident.

To further provide against accident in case the cable should break, a magnet (Plate IV) operated by an electric current passing through one of the wires in the electric core, is placed in the car. The magnet supports an armature weighing 22 lbs., and in case the current breaks, the armature drops upon a disc at the end of hand rope and pulls the latch of the safety device.

Electric Core.

The electric core contains two No. 16 copper wire conductors, each made up of four wires, and one similiar steel wire conductor. Each strand is covered with tape and is thoroughly insulated. The outside diameter of the core is ⅝ inch. There being no precedent for the use of an electric conductor in this manner, the various electric cable manufacturers refused to guarantee the results and much doubt was expressed as to the possibility of making a cable that would answer the purpose. The first cable was made with a core exactly as described above except that the three conductors were single No. 16 copper wires. When placed in operation the electric wires operated only about four days when all three wires broke. A second cable was ordered with the alterations as indicated above and in the meantime the road was operated by means of hand signals from the top of the car and electric signals through an overhead wire between the two ends of the roads. The new cable was inserted November 8, 1891, and up to date the two copper wires are in good condition. The steel wire broke during the manufacture of the cable.

The upper end of the steel cable being fastened to the drum, the

electric core is brought down to the shaft of the drum and passes through a hole drilled longitudinally into the shaft, emerging at the end of the shaft (Plate IV) where the wires are attached to the brass rings which are in contact with brushes, from which latter the wires lead to the bell and batteries.

SERVICE.

The number of cars transferred varies greatly. At present they average about forty cars, whereas in summer they transfer from sixty to eighty cars per day. By the terms of the City Ordinance authorizing the construction of the road the company is required, at the request of the owner of any property fronting on said railway, to transfer cars from the main track to such property and *vice versa*. It is expected that such a service will be developed in the future, and plans have already been submitted by one of the property owners along the line; but so far, such cars as have been transferred for parties other than the brewery have been delivered in the upper yard.

The first day the road was operated an unexpected difficulty occurred. The lower end of the line being built on a comparatively slight grade, and the friction in passing around the curve being considerable, the grip car developed a tendency to stop on the down trip, before reaching the end of the line. It was finally decided to let the car down with sufficient speed so as to obviate the danger of a stoppage before the car should reach the lower end. This was done forthwith. The car was pulled up on the steep grade and let down with a flourish. The speed kept on increasing at a rate such that some of the men became frightened and jumped off, and others rushed to the brakes and finally stopped the car. No further thought was given to the occurence for the time being, and a coal car was switched in and taken up the hill. The grip car was then lowered again, with a view to making another trip. Before the next trip was made however an inspection of the grip plate disclosed the fact that a serious difficulty had arisen. In attempting to lower the grip car with all possible speed the engineer at the hoisting engine, anxious to give the car all the rope possible, had unknowingly unwound several coils of cable into the pit. This accounted for the uncontrolled speed of the grip car. When the car was finally stopped the cable kept on going and doubled up under the car; and when the cable was again pulled taut, it looped around the grip plate, lying partly below the lower end of the plate. This was not discovered until after the next trip when the grip was inspected, as the cable is all under ground and not visible except through the slot or man-holes. The clearance between the bottom of the grip plate and the vertical sheaves being only about $\frac{3}{8}$ inch, and the rope now being doubled up under the grip plate, in going up hill a number of the vertical sheaves were either broken or damaged. The writer

was on the car at the time and he remembers feeling a series of thumps at regular intervals. As the street had been newly macadamized he supposed that the commotion was due to stones on the track, but was somewhat surprised at the regularity of the occurrence. Each thump meant another sheave demoralized. To prevent the recurrence of the accident a simple contrivance was designed which notifies the engineer the moment he has any slack rope in the pit. (Plate V). A long board with the ends resting upon springs, is placed across the pit and just below the normal position of the cable. Electric push buttons are placed at either end of the board. The moment the cable becomes slack it rests on the board, and an electric bell rings continuously until the engineer takes up the slack. No further trouble has been experienced since the introduction of the electric tell-tale.

Cost.

Following is a table giving the cost of the work:

CONDUIT TRACK.

Excavation.		
3,850 cubic yards, @ 58c		$ 2,219.39
Concrete. 942 cubic yards.		
Cement, 713 Bbls., @ 3.20	$ 2,281.60	
" 271 " @ 3.08	834.00	
Macadam 200 squares, @ 5.00	1,000.00	
Sand 365 cubic yards, @ .60	219 00	
Labor	896.10	
942 cubic yards Concrete, @ 5.55+		5,230.70
Track, 1,872 lineal feet.		
85 ℔ T Rail, 51 tons, @ 36.00	$1,839.70	
Freight on same	178.86	
53 ℔ Slot Rail delivered, $32\frac{1212}{2240}$ tons @ 50.00	1,627.05	
Bolts, Shims, &c	497.00	
Labor	946.50	
Castings for Broadway Crossing	1,100.00	
Yokes, 273,174 lbs., @ 1.55	4,234.20	
Manhole frames and covers, 53,338 lbs., @ 1.75	933.42	
Sheaves and frames, 16,276 lbs., @ $6\frac{2}{3}$c	1,085.06	
Rack Castings, 29,053 lbs., @ 3.5c	1,016.86	
Extra Castings, Depression Sheaves, &c	661.46	
1,872 lineal ft. track, @ 7.54+		14,120.11
Paving for Conduit Track.		
Granite Blocks, 80 squares, @ 18.75	$1,500.00	
Labor	407.51	
Sand	250.00	
80 squares Paving, @ $26.969		2,157.51

Repairs on Potomac Street.		
Macadam, 300 squares, @ 3.75	$1,126.87	
Gravel, 50 squares	212.40	
1,872 lineal feet of Conduit Track, complete, @ 13.40		1,339.27

SWITCH TRACKS IN UPPER AND LOWER YARDS.

Rails.		
63 lb. T. Rail, 85 tons, @ 33.00	$2,805.00	
Freight on same	297.50	
Bolts, fish plates, etc	816.00	
Switches, Frogs, etc	2,518.00	
Timber.		
Stringers, ties, etc., in upper yard	2,139.00	
Planks in lower yard	746.00	
Macadam.		
563.5 squares, @ 3.50	1,972.00	
8.5 squares, spalls	22.00	
227 squares macadam, @ 3.75	851.00	
Paving. (Upper yard.)		
15,000 Granite Blocks, @ 5c	750.00	
Pavers	188.00	
Excavation, 2,675 cubic yards, @ 30c	802.50	
Laying Track, 7,700 feet	6,474.71	
Sewerage	909.00	
Tools and repairs of same	829.64	
7,700 lineal ft., switch track complete, @ $3+		22,120.35
Cable Rope		703.80
Grip Car		2,470.27
Hoisting Engine (foundation not included)		7,100.00
Crossing Gate, House, etc		397.00
Miscellaneous		481.30
Total cost		$58,339.70

The cost of engineering and superintendence is not included in the above. All the material was purchased by the company through their engineers, who obtained the bids and wrote all of the contracts. The labor was furnished by a local contractor who was allowed 15 per cent. on the cost of the labor. This is included in the estimate given. The engineers had full charge of the work and received as compensation a percentage of the cost of all material and labor used in the work.

THE BEHAVIOR OF IRON COLUMNS AT HIGH TEMPERATURES.*

By A. Gottlieb, Member, Western Society of Engineers.

[Read March 2, 1892.]

The great importance for our modern architecture involved in the question how iron columns will behave, when exposed to high temperatures, was the cause of a series of practical experiments conducted toward the end of the year 1886 by the Government Architect Mr. M. Moeller, and the author of this paper in Hamburg.

It is known that after a conflagration of some magnitude in Berlin, cast iron columns were found cracked and broken into pieces. It was assumed that this destruction of the columns was due to the effect of the cold water poured upon the heated columns. This was the incentive of the order issued by the Building Department of the Berlin municipality, prohibiting the use of cast iron columns, if not fire proofed, for stores or other parts of buildings, over which inhabited apartments are located.

The same year (1884) Professor Bauschinger in Munich experimented on columns, cast iron as well as wrought iron, by first heating them to a temperature of 1112 degrees Fahrenheit, and then pouring water on them. The specimens at the disposal of Professor Bauschinger were cast iron columns, rejected on account of very uneven thickness of metal, cold shots and other defects. Of still inferior quality were the wrought iron columns, being tubes of comparatively small diameter and small thickness of metal, or struts formed of two channels, or two I beams, connected together by a few bolts.

For the computation of the stresses Bauschinger properly used the formula of Schwarz, and not Euler's formula, which for columns with jointed ends is as follows:

$$P = \frac{\pi^2 E J}{l^2}$$

P = Ultimate strength.
E = Modulus of elasticity.
J = Least moment of inertia.
L = Unsupported length.

This formula is correct only, when the line of pressure coincides with the neutral axis of the column, which, however occurs very sel-

*From a paper read by Engineer R. Luehmann. before the Society of Engineers and Architects at Hamburg. Translated from the "*Deutsche Bauzeitung*" of 1888.

dom, and merely accidentally in columns in Buildings. The working resistance of the materials is not defined in this formula: this must be remedied by the Auxiliary formula of

$$P \leqq \frac{1}{n} F\ S$$

in which F is the sectional area of metal, S the ultimate strength of the material and n the factor of safety.

The proof that this formula should not be adapted for practice, can be demonstrated best by an example. Let us assume a cast iron hollow column of square section, the side of square 11.81 inches, the thickness of metal 0.787 inches, for which $F = 34.72\ \square''$, $S = 99{,}300$ pounds per square inch, $n = 4$, $P\ n = \frac{S\ F}{n} = 861{,}924$ lbs. The greatest length of a column to resist this load with a factor of safety of four is $l = \frac{\sqrt{\pi^2\ E\ J}}{P}$ which in this case, taking E at 14,000,000 would give a column of about 14 feet. In other words, according to this formula it would not differ whether the column is five, ten or fourteen feet long.

This certainly is not correct for structular pillars, in which through eccentric loading, greater stresses are produced in the various sections. Such stresses are considered in the formula of Schwarz, which is as follows:

$$P = \frac{1}{n}\ S\ F \frac{1}{1 + K \frac{F\ l^2}{J}}$$

n = factor of safety assumed as five by Bauschinger; S = ultimate strength per square inch, assumed by him as 99,400 pounds for cast iron, and 56,800 pounds for wrought iron; consequently $\frac{S}{n}$ for cast iron = 19,900 pounds and for wrought iron 11,360 pounds. The co-efficient K has been determined by Bauschinger for cast iron as 0.0006 and for wrought iron 0.00009.

From his experiments Bauschinger draws the following conclusions: "I find from my experiments that wrought iron columns under load, even with the most perfect mode of fastening or support of their ends, partly already when subjected to a heat of not quite 1112 degrees Fahrenheit, but certainly at the slightest red heat, irresistibly deflect towards the fire, which deflection increases when water is thrown on the opposite side of the columns, even if the water is applied to the ends of the columns only; the structure supported by them must collapse.

Although cast iron columns under the same conditions, as to supports, also deflect towards the fire, and this deflection also increases under the application of water, still this deflection does not exceed a certain limit, even if the whole column has been red hot, and the wa-

ter is occasionally applied to the center of the column. The column never ceases to support its load even then, when through the application of water it is cracked, often considerably cracked. During the cooling, while yet squirted with water, the columns again straighten almost completely.

Only in the case where both ends of the columns are rounded, and free to move in every direction, do they bend sufficiently, so as to break, if they are first brought to a red heat through their entire length, and while so heated water is energetically applied in the middle."

These statements of Professor Bauschinger are partly excepted to by Government Architect Moeller, in his publications contained in the "*Centralblatt der Bauverwaltung*" (Central Organ of the Department of Buildings) of 1886, No. 162, and in the "Deutsche Bauzeitung" of 1886, No. 53 and No. 55.

Mr. Moeller primarily notices that the proportions of the wrought iron experimental columns were unfavorable, compared with those of the cast iron pieces. Certain it is, that so differently proportioned pieces as these tests pieces were, could not be compared with each other without further consideration.

Mr. Moeller also objects to the great difference in the numerical value of the co-efficient K as assumed by Bauschinger, which for cast iron is almost seven times as large as for wrought iron. Thereby the value of $\frac{K\ F\ l^2}{J}$ for cast iron is considerably greater than for wrought iron, consequently P smaller, and also the extreme fibre strain smaller.

If z represents the eccentricity of the force, $P\ z$ the bending moment, $\frac{J}{a}$ the moment of resistance, then $P\ z = \frac{J}{a}\ S$ and the maximum strain in extreme fibres: $S \text{ max.} = \frac{P}{F} + \frac{a\ P\ z}{J}$.

From this formula Moeller computed the extreme fibre strains of Bauschinger's experimental columns, and found that the slender wrought iron columns deflected considerably more than the cast iron columns, and consequently had to resist a greater eccentricity of force, causing larger strains in extreme fibres.

The question now arose for Mr. Moeller to determine the value of K under the supposition of a one sided heating of columns, as it occurs at fires. These new values were determined from the deflection of columns under the supposition, that one side was heated 1112 degrees Fahrenheit more than the other side. Greater heats than 1100 to 1300 degrees could not well be considered, because cast iron melts at 2000 to 2200 degrees; and wrought iron burns at a heat of 2300 to 2400 degrees Fahrenheit. The mode of procedure was, that first the radius of curvature, and from this the deflection of the columns and the ef-

fect of the eccentric force were computed. The value obtained is then substituted in the formula for S max. and then P computed. The result was that when

$$\frac{L}{D} \leqq 8 \begin{cases} \text{for wrought iron } K = 0.00038 \\ \text{for cast iron } K = 0.00034 \end{cases}$$

when

$$\frac{L}{D} \geqq 26 \begin{cases} \text{for wrought iron } K = 0.00043 \\ \text{for cast iron } K = 0.00043 \end{cases}$$

L and D are length and diameter of columns.

It is apparent that the values differ but slightly, and it will be proper, on account of some slight omissions and approximations to assume S for all cases as 0.0004.

Mr. Moeller also recommended to adopt for S for cast iron 10,000 pounds per square inch. S for wrought iron 14,000 pounds per square inch. It may be remarked right here that these co-efficients were increased later, after subsequent experiments.

In 1886 Professor Bauschinger made a second series of experiments, differing from the former in the first place through the fact, that the experimental columns were of fair quality. Unfortunately, however, the wrought iron pieces again were small in their lateral dimensions, compared to their great length of nineteen feet. As the cast iron columns were only thirteen feet long, the experiments were made again with specimens, which cannot be compared without further consideration. As before Bauschinger adopted for wrought iron the coefficient $K = 0.00009$, but for cast iron he assumed it $= 0.00025$ as quoted by Laissle and Schuebler, because the experimental columns were of better quality, than in the first experiments.

It will be noticed that the latter co-efficient is considerably smaller, than assumed by Moeller, whereby the theoretical value of the columns is increased. The cast iron columns, however, stood the fire very well, as they carried the whole of the computed load at a red heat, while at the same time being squirted with water; in particular it must be mentioned that they showed no sign of cracking. But also the wrought iron columns, which were also of considerably better quality, than in the first trial, stood better, and the final results, according to Professor Bauschinger, were as follows: "Wrought iron columns, of good construction, can resist the action of fire and water pretty well, but not quite as well as cast iron columns. Wrought iron columns of inferior construction, however, in which the connection of the component parts are not very thoroughly effected, are bent and destroyed under the action of the loads. As to the shape of the cross section, the box column is preferable to the cross shape." These second series of tests of Bauschinger are discussed by Moeller in a paper in the "Deutsche Bauzeitung" of 1886, No. 83. From what was said by him about the first experiments, it cannot well be doubted that Mr. Moeller would draw the same conclusions from the second experi-

ments, and he summarizes them in the following manner: "Experiments which are to demonstrate whether wrought or cast iron columns are better adapted for use, must be made with test pieces which will permit a direct comparison. The test pieces of wrought iron must have the same length and lateral dimensions, and the same moment of inertia as the cast iron test pieces."

Thus the opinions differed when in 1886 the "Society for the promotion of Industrial progress" offered a prize for the best essay on the subject of the "Resistance of Iron Columns when subjected to high temperatures." The program issued contained the following remarks: "Cast iron columns have been largely used in recent years for architectural purposes. They are an important factor for the free development of architecture, as well, as they are an interesting and profitable object for a flourishing branch of an industry, related to constructions. Meanwhile there have been objections raised against their use, caused by observations made during certain conflagrations. It is particularly feared that they may crack if, when heated at a great fire, they are plied with cold water. For this reason it was ordered by the Police District of the City of Berlin, that in buildings in which the lower portions are used for stores or warehouses, and the upper portions for dwellings, cast iron columns for the support of upper walls are prohibited, unless they are protected by a wrought iron shield, with an air space between it and the column; otherwise either wrought iron columns or masonry piers of hard burned brick, laid in cement mortar, must be used. On the other side it is claimed that wrought iron columns, consequent on the small thickness of the metal used, usually get heated quicker and break at lower temperature than cast iron columns, which latter not only resist successfully a moderate red heat, but also the effects of bending moments while in that condition. For this reason wrought iron columns are considered as less safe than cast iron columns, and it is believed that only such cast columns should be avoided, which are either cast from poor metal, or are defective in their proportions, or in their molding or casting. It is therefore intended that, as far as possible, it should be demonstrated by experiments how wrought iron columns behave when subjected to sudden cooling while at high temperatures, and of what shape and section they ought to be, to resist most successfully such conditions.

It ought also to be shown, what degree of safety may be expected from masonry piers in comparison with either wrought or cast iron columns.

Mr. Moeller, as well as myself (Enginéer R. Luehmann) competed for this prize, and, as is well known, obtained the same.

Before entering upon a detailed account of the experiments and their results (the theoretical demonstrations of which were left to Mr.

Moeller exclusively) it may be proper to state to what extent it was found the co-efficients referred to above, have been proven to be correct. In the first place the co-efficient $K = 0.0004$ was found to be correct; on the other hand, however, it was found that the strains of extreme fibers are to be taken considerably higher than heretofore assumed: thus for cast iron $\frac{S}{n}$ not 10,000 but 21,000 lbs.; and for wrought iron not 14,000 but 16,800 to 19,600 pounds per square inch, if in the computation of columns the high temperatures are to be considered. As the supports for all of the experimental pieces were so arranged, as to cause the line of action of forces to be eccentric by about 0.4 inch with reference to the neutral axis of the piece, so as to make the experiments under as nearly the same conditions, as they may occur in actual use of columns, it was desirable to have another formula, which would give expression to this eccentricity of forces and the bending moments caused by them. This formula also was developed by Mr. Moeller and is as follows:

$$P = S F \frac{1}{1 + \left(\dfrac{a + \left(\frac{l}{2}\right)^2 P a}{2 C J - \frac{5}{6}\left(\frac{l}{2}\right)^2 P} \right) \dfrac{F u}{J}}$$

in which formula F = sectional area.

$\frac{J}{u}$ = the moment of resistance.

J = moment of inertia.

P = ultimate strength.

S = strength per square inch.

l = length.

a = eccentricity in beginning of loading.

C = modulus of elasticity.

This formula was very valuable for checking the results of experiments made at normal temperatures; but it is somewhat cumbersome, as the computations had to be made by approximations of P, for which purpose the first value was computed by Eulers' formula. The experiments further showed that for S the following values should be used.

a, for Cast Iron.

1st. For hollow columns cast horizontally and of slightly uneven thickness of metal.

$\frac{L}{D} \leqq 15$	15 / 20	20 / 25
S = 61,000 lbs. per 1 □″	58,900	56,800

2nd. For hollow columns.

$\frac{L}{D}$ =	15	15 / 20	25 / 30	35 / 40	40 / 45
S =	106,400	85,200	56,800	28,400	21,300

b, for Wrought Iron.

For soft wrought iron S = 31,200 pounds.
For medium hard S = 42,600 pounds.
For riveted sections recommended 38,000 pounds.

For every test specimen the computations were made from the new formula of Moeller, as well as those of Euler and Schwartz, so as to compare the computed values with those derived from the experiments.

We agreed at the beginning of the experiments that the test pieces ought to be of such dimensions, as they occur in actual use. We began with a wrought iron tube of 5-$^9/_{10}$ inches outside and 4-$^{72}/_{100}$ inches diameter equal 9-$^{55}/_{100}$ square inches section; all of the other test pieces had the same sectional area of metal of 9-$^{55}/_{100}$ square inches, with the exception of the solid wrought iron columns, which were of solid rolled round iron, which had a section of 9-$^{61}/_{100}$ square inches. The test pieces were hollow or solid; the latter were of 3-$^{54}/_{100}$ diameter for cast iron and 3-$^5/_{10}$ for wrought iron; the former as above stated of 5-$^9/_{10}$ inches diameter. We further had riveted pieces of four angles and two plates, latticed on the open sides. The angles were 2.25 × 2.25 × 0.31 inches, and the plates 4.52 × 0.51, and the lattice bars or stay bars 1.96 × 0.31 inches. It was intended to ascertain what effect a cement filling of the column would have, as it was believed that cracked cast iron columns would retain their shape if so filled. In one of the columns a wrought iron tube was inserted in casting the columns, as that was considered still better than cement filling. It was also determined to test the value of outside covering of column, for which purpose the column was incased in wood, which in turn was surrounded by sheet iron; several of the columns were protected by a cement covering. Furthermore an ornamental grooved cast iron column, with ornamental capital was tested, to ascertain what effect ornamentations may have. The test pieces selected were either:

1 meter = 3.28 ft.
2 meter = 6.56 ft.
or 4 meter = 13.12 ft.

The first length was selected to determine the crushing strength of the material, as with that length the influence of flexure is but small; the second because its proportion to the lateral dimensions of the test pieces was about the same as for columns in actual use; the last because its great length was to demonstrate the danger incident to such proportions; further we tested piers of hard burned brick, one of them

containing a block of granite and sand stone, and blocks of oak and pine timber; in all forty-three pieces were tested. In order to determine the difference between the safe load for a column when in normal and in high temperature, two equal test pieces were tested: one in normal and one at high temperature, and the test every time extended until the column was destroyed. All the main test pieces were tried with rounded end supports: but, to show the difference, several were tested between parallel supports. It ought to be also stated that all iron test pieces were truly faced at the ends, and the castings were cast in a horizontal position.

Description of the Apparatus and other auxiliary means.

The hydraulic testing machine used had a capacity of 440,000 pounds which is reached at a pressure of 100 atmospheres. The piston had a diameter of 20 inches: the two wrought iron tension rods are provided at both ends with steel wedges, and are so arranged, that test pieces of various lengths can be accommodated. As it is impossible to fix the direction of the pressure, without using rounded ends, it was determined to test all specimens with such ends; for this purpose semispheres and semispherical hollow caps of cast iron were employed. The semispheres, which were neatly finished, and were kept well lubicated, formed a part of a strong casting, which was fastened to the piston at one end, and the cross head of the machine at the other; they worked to perfection. The back ends of the hollow caps were provided with a rim so arranged, that the test pieces could be fastened on it, so as to be one centimeter (0.39 inches) eccentric, and the pieces so placed that the eccentricity was downward, to avoid any danger when the pieces broke. It is to be noted that in computations the length of the specimen was always assumed from the middle to middle of rounded end support. For measuring the pressures three manometers were used, which were divided for pressures up to 6, 30 and 200 atmospheres respectively, and were used either singly or in pairs.

Through careful observations it was ascertained that the loss of power through friction did never amount to more than five per cent.; this percentage was deducted however, in each case from the indicated pressure. The deflection was measured with a dial, the pivot of the indicator being on one of the tension rods, and the proportion of arm 1 :4. This enables to use a scale where 1 mm, was represented by 4mm, so that it was possible to read fractions of a millimeter. As the vicinity of the pivot remained cool, and only the short, thick, end of the lever was exposed to some irregular heating, the indications of the other end of the dial hand were very little affected by the heat, and it was shown that the variations could not have amounted to more than 0.1 or 0.2 mm. The horizontal deflections were not measured, as the vertical deflections only were of interest, the eccentricity being placed

downward and the heating occurred from below. For measuring of the temperature a little lump of lead was used whose melting point is known to be 626 degrees Fahrenheit. This lump was clamped to a bar so as to be in contact with the test specimen. When the lump melted it was evident, that the specimen had been heated to at least 626 degrees. In the same manner an alloy of 39 parts of silver and 61 parts of lead were used, which according to Professor Bauschinger, melts at a temperature of 1112 degrees Fahrenheit. At this temperature iron shows already a distinct red colored heat.

The test specimens were bedded in heating crates, with a grate bottom throughout their entire length, provided with round holes, so that the metal lumps for measuring the temperature could be inserted, and the pieces could also be watched from the side. In order to expose the upper parts of the pieces to the action of the flames, wood was also piled along the side of the test specimen. At a conflagration. such high temperatures, as were used at these experiments, will only occur when there is a draft of air, as will take place when wooden parts have fallen in a heap and are burned.

Test Results.

1st. Cast iron column of 1 meter length, $5^{9}/_{10}$ inches outside diameter, $4^{72}/_{100}$ inches inside diameter.

Tested Cold.

The column was in so far defective, as its metal was of uneven thickness, being 1 centimeter on one side and 2 centimeters on the other. This column was put in the testing machine first with the thicker side upward, so that the initial eccentricity of the force was small. At 106.6 atmospheres equal to 451,630 pounds, the deflection downward was 0.236 inches: then the pressure was changed to 13.1 Atm., equal to 57,200 pounds, when the deflection was still 0.157 inches. Then the piece was taken out, proved to be uninjured, and replaced in the testing machine with the thin side upward, at which the eccentricity of the force was 0.033 inches. The tube broke at 101.6 Atm., equal 430,452 pounds, with a deflection of 0.984 inches. The fracture took place in the upper fibre of the metal; the fracture showed a shelly formation while in the lower side, which broke by tension, the fracture was of the usual granular shape. The maximum extreme fibre strain for the compressed portion was computed to be 113,400 pounds per square inch.

2nd. The same size cast column as before, at high temperature. Thirty-nine minutes after kindling the fire the column was red hot on the underside. The pressure applied was 25.4 (100,000 pounds) whereby the deflection increased from 0 to 0.185 inches. Then the column was plied with water for two and one half minutes, when the deflection increased to 0.335 inches. After the application of water ceased

the deflection decreases, and then the heating is renewed, when after a lapse of thirty-six minutes, the deflection is reduced to 0.039 inches; and then water applied again. The tube is now bent upwards, the pressure is increased, and the tube is cracked on the top side and breaks at 35.6 to 41.6 Atm., equal to 155,000 to 176,000 pounds, with a deflection upwards of 0.984 inches. Here the upper side of the tube broke under tension, and did not show the shelly fracture.

3rd. Tube of the same dimensions as No. 1 and No. 2, but of wrought iron.

Testing Under Heat.

The tube is red hot at the underside after sixteen minutes: the pressure is 102,000 pounds, the deflection 0.137 inches; it decreases to 0 and finally is 0.017 inches upward. Then water is applied for three minutes whereby the bending upward increases to 0.57 inches, During the application of water the pressure had to be reduced 86,600 pounds. The pressure again being increased the tube is entirely bent at 31.4 Atm., equal to 133,760 pounds. It had no strength after this and could not resist the pressure. The pressure being reduced to 20 .5 Atm., the bending upwards was 4.5 inches, when the test piece jumped the bearings.

4th. Cast Iron 2 meters long (6′ -6 ¾″), the same diameter as before $5^9/_{10}$ inches outside, $4^{72}/_{100}$ inside.

Tested Under Heat.

Pressure up to 15.4 Atm., equal to 65,000 pounds, deflection 0 to 0.9 inches. After thirty minutes the column is red hot underneath, when water is applied for one minute and the deflection increases to 1.1 inches. Then the pressure is increased when the column breaks at 51.6 Atm., equal to 218,000 pounds, and a deflection 2.56 inches downward; the pressure just preceding the fracture being 54.6 Atm. The column was red inside, the fracture in the lower half, in the vicinity of a core support, showing many blow holes.

5th. Wrought Iron Tube, 2 meters long, same diameter as before, $5^9/_{10}$ and $4^{72}/_{100}$ inches.

Tested Under Heat.

Pressure held as before to 15.4 Atm., equal to 65,000 pounds, deflection to 0.944 inches. After a lapse of fifteen minutes the column is red hot on the underside. Water is applied when the following deflections downward take place: 0.984; 1.181; 1.456; and 1.378. The column is heated again and in fifteen minutes the pressure of 15.4 Atm. is again applied, when the deflection downward is 1.023 inches. Water is again applied and the pressure increased when at 25.4 Atm., equal to 106,000 pounds, the column is completely crippled at a deflection of 1.97 inches.

6th. Cast Column 2 meters long, diameter 5.9 and 4.72 inches as

before, filled with cement mortar (composed of one part cement to one part sand.)

Tested Under Heat.

Pressure 20.5 Atm., equal to 86,000 pounds; deflection 0.078 to 1.22 inches. After eighteen minutes the column is red hot underneath. As the cast iron column never showed any cracks it was determined to test this piece with particular care with reference to cracking. For that reason the column after futher heating for four minutes, was turned so that the red hot side was on top. Six pails of water, in a sharp well directed stream were thrown upon this red hot part. The tube remained whole and was then tested to destruction. The deflection could not be measured, as the column was turned over and the indicator removed. At 61.6 Atm., equal to 260,000 pounds, there was a detonation and explosion. The mortar had been wet yet, and the close fitting end bearings preventing the escape of the steam formed inside the tube, caused the explosion. The tube proved somewhat stronger on account of the inside filling.

7th. Cast column, as before 2 meters long, 5.9 and 4.72 outside and inside diameter, filled with cement mortar (One part cement to three parts sand) and through the cement a wrought iron pipe of 2.36 inches outside diameter and 0.118 inches thickness of metal, also filled with cement mortar.

Tested Under Heat.

At a pressure of 20.5 Atm., equal to 86,000 pounds, deflection 1·1 inch. After thirty minutes the column is red hot underneath. Water is plied upon the under side, but no cracks are caused. After fourteen minutes more the column becomes red hot on the sides also. Water is thrown upon the sides but no cracks appear. The pressure is increased when at 51.6 Atm., equal to 218,600 pounds and a deflection of 1.73 inches, the column breaks. Immediately before the fracture the pressure was 46.6 Atm., equal to 195,700 pounds and the deflection 2.36 inches. The fracture is close fitting, and the two parts are held together by the wrought iron pipe inside. The whole is lifted up with a crane, taking hold of one end, but both parts remain together in the bent condition as they were. When the tube was put on the floor the two parts closed up perfectly. According to the result of this test a Cast Iron Column will remain servicable, when cracked by heat, if in the middle a small wrought iron pipe is cast with the column.

8th. Cast Column, 2 meters long, 5.9 and 4.72 outside and inside diameter as before. The column outside protected by a cement mortar coating of 0.236 inches (one part cement to three parts of sand.)

Tested Under Heat.

Pressure 30.4 Atm., equal to 127,600 pounds, deflection 0 to 2.21

inches upwards. After fifty minutes water is applied and the heat continued. The coating is heated below, and although many parts of it drop out, the column withstands the heat very well for thirty-five minutes more in full fire, but after further five minutes it must be broken on account of lack of time. Pressure at fracture 66.6 Atm., equal to 282,200 pounds with a deflection upwards of 1.18 inches. A column like this, but unprotected by coating, broke hot at a pressure of 231,000 pounds.

9th. Wrought Iron tube, 2 meters long, outside and inside diameters 5.9 and 4.72 inches respectively as before. Protected outside by cement coating of 0.236 inches thickness, (one part cement to three parts sand).

Tested Hot.

Pressure of 20.5 Atm., equal to 86,000 pounds, deflection 0.878 inches upwards. After thirty minutes the coating underneath is amlost at white heat. Water is applied on the top and on the sides, whereupon the coating splits on the sides. Then the heating is continued, and after one hour and thirty-five minutes more, the tube is destroyed on account of lack of time. Greatest pressure 51.6 Atm., equal to 218,600 pounds. The greatest pressure for a similar tube when cold was 227,000 pounds. The tube would have stood well for sometime yet, as after taking the same out, while the coating was still heated, the interior of the tube was cool enough to permit the introduction of the hand.

10th. Riveted Colnmn, 2 meters long, protected by a shell of wood 1.17 inches thick, and sheet iron cover of 0.039 inch thickness. Pressure kept at 20.5 Atm., equal to 86,000 pounds, deflection 0 to 2.27 inches upwards. After thirty-three minutes the coating is red hot on underside. After forty-three minutes it is almost at a white heat. After an hour water is thrown on top, and after an hour and three minutes the column is destroyed. Greatest pressure at 71.6 Atm., equal to 301,000 pounds, and a bending upward of 2.36 inches. After removing it from its bearings the column is scarcely at boiling heat; the wooden covering is entirely charred on the underside and half charred on top. All three specimens protected by a coating showed therefore very good results. In the following we give the results of a few experiments, for comparison, in which the bearings of the specimens were fixed or square.

11th. Ornamental cast column, 5.9 outside diameter, 4.72 inside diameter, 2 meters long.

Tested Under Heat.

Points of support eccentric, pressure kept at 25.4 Atm., equal to 105,600 pounds; deflection downward 0 to 0.41 inches. After eighteen minutes the column is red hot underneath. Water is applied for one

and one half minutes when the deflection increases to 0.51 inches. After twenty-eight minutes water is applied from below. No cracks appear and the column is bent upward 0.27 inches. Now a keg of water in a smart stream is plied upon the base, one on the cap and one on the center of the column. No cracks are visible. The column is again heated and tested to destruction. It breaks at a pressure of 86.6 Atm., equal to 370,000 pounds, and a deflection of 1.57 inches.

12th. Cast column 2 meters long, 5.9 outside, 4.72 inside diameter.

Tested Under Heat.

The column was so placed in the testing machine that its centre axis was 0.67 inches below the centre line of piston; pressure kept at 30.4 Atm., equal to 127,600 pounds; deflection 0 to 0.196 inches upward. After twenty-seven minutes the column is red hot: water is applied from above for one and one half minutes: the deflection increases to 0.395 inches. After thirty-eight minutes the pressure is increased to 76.6 Atm., equal to 324,500 pounds with a bending upward of 1.57 inches. As it became dangerous to make observations the column was not tested to destruction. A similiar column broke with rounded supports at 231,200 pounds.

1 . Riveted column, 2 meters long, tested between parallel supports exposed to fire on all sides. The plates were on the upper and underside; pressure kept at 15.4 Atm., equal to 63,800 pounds. deflection 0 to 0.354 inches downward. After forty minutes the column is red hot underneath, water is plied upon it, whereby the deflection recedes to 0.255 inches. The pressure is increased to 20.5 Atm., equal to 86,000 pounds. After forty-seven minutes the column is again red hot, and after a second application of water the deflection receded to 0.039 inches downward. The column is then tested to destruction. with the following results:

Pressure 40.8 Atm., deflection upwards 0.78 inches.
Pressure 40.8 Atm., deflection upwards 1.17 inches.
Pressure 28.4 Atm., deflection upwards 1.14 inches.
Pressure 25.4 Atm., deflection upwards 4.72 inches.
Pressure 20.5 Atm., deflection upwards 5.51 inches.
Greatest pressure 40.8 Atm., equal to 172,700 pounds.

This concludes the translation of Engineer Luehmanns Paper. I was induced to select this Paper and come forward with a translation, rather than an original essay on some other subject, because I hold that its contents are of great importance, and deserve careful consideration on the part of the Profession in this time of unprecedented use of metal in the construction of buildings. The Paper contains data derived from careful experiments, which ought to help us to arrive at correct conclusions as to the use of cast and wrought iron for building purposes, and the value of protecting such material against the action

of heat. Believing the Paper of such merit as to be worthy to be brought to the notice of American Engineers and Architects, I have taken pains to translate the same, at the same time transforming all the metric figures into our own standard measures, which is the only credit I claim in bringing this Paper before the Society.

SOME TRIALS AND RESPONSIBILITIES OF THE ENGINEER.

Address Delivered by Retiring President, Mr. E. H. Wilson, Montana Society of Civil Engineers.

[January 9, 1892.]

In taking leave of you as president to-day I wish to lay to the door of business cares and occupations my non-attendance at many of our meetings. The year has been a prosperous one for Montana and I doubt not that I may congratulate you all, fellow members, upon sharing to the full Montana's prosperity, for the various new enterprises and continued successes of older ones are intimately associated with the labors of the profession. During the year many new works in all fields of labor have been inaugurated. A comparatively local road has projected itself westward and promises, thanks to the genius and wisdom of the hands controlling it, to be one of the best transcontinental lines. This enterprise, rendering fertile the latent resources of a comparatively unknown country, opens to us and to all Montana a vast field of usefulness and profit. New mining enterprises of rare promise and fruition, in which engineers have done their part, have added to the fame of the state. The time is upon us when the finer instincts and abilities of the engineer must take the place of rougher rule of thumb, which has sufficed heretofore; and here, gentlemen of the society, I would say a few words as to what, I submit, should be our duties as engineers, to ourselves, to our society and to our employers.

Clients have been too much led to think that the engineer's place in an enterprise is one of a machine; that he may possibly be relied upon to furnish distances, directions and elevations which, submitted to the client, may be used in the finer calculations which properly constitute engineering, and which by some hidden instinct the client passes upon. Take the irrigation question which is now agitating the state. The engineer is employed to direct the level and is too often relegated to the position in the enterprise of a machine. The estimation of the flow of water, the choice of grades for his canal, its dimensions, (depending upon many things really, character of material, etc.,) the methods of deflection—all these essential elements in the plan are passed upon

too often by the projector, who assumes what should be the function of the engineer, and places that employe in the mere place of a collector of data. No engineer of proper respect for his profession should permit this or should allow his name to be connected with an engineering plan (unless pushed by hunger) which ignores his profession.

One of our canal enterprises has become notorious as an example of failure,—large sums of money invested in constructing a work which was useless from the lack of water to fill it. Such mistakes reflect too often on the engineer, when really he has little to do, beyond driving stakes, in the enterprise. We all doubtlessly are employed as surveyors, but in whatever capacity we find work, let us take a pride in doing it well and thoroughly. Those coming after us will not go further than our names in criticising adversely poor work with which we have been connected. If it is only the measurement of a line, do it well. If it is only the setting of a stone, do it thoroughly. If it is only the re-establishment of a section corner refuse to allow the hurry of an employer to connect your name with faulty work. Carry common sense with you everywhere and remove the reproach too often heard in comments of the ignorant upon the difference between theory and practice. You will have enough to bear in any event. Even the track layer is disposed to sneer at us, because in his experience some so-called engineer has wanted him to cut a rail, to place a frog, instead of placing it at the right joint and shaping his survey accordingly.

A notable instance of blaming the engineer for results for which he was not responsible occurred in my own experience some years ago. When the first smelter at Anaconda was in course of erection, I was called upon to locate connections therewith. I got such figures from the smelter people as to tonnage to be delivered above their works, as warranted me in locating such a grade as, avoiding heavy rock-work, made it possible for one engine to do all the switching in the Anaconda yard, with ample margin for contingencies. The road was built: the smelter started: and then came the additions to its capacity as the mine developments warranted. The first contemplated treatment of 300 tons per day was increased to 500, to 1,000, to 1,500 and more, and our steep grade was found provoking and costly. Were the original figures of a smelter considered in hunting a scape-goat for a mistake in judgment of everyone but the engineer? No. The engineer who located such a grade was unqualifiedly condemned.

So you will find always. If a scape-goat for some failure is wanted it is too often the engineer's name which is sought. Do not the ridiculous mistakes of the Union Pacific in climbing summit after summit in order to finally get back to the waters of the North Platte still stand as a monument of incapacity to its engineers? And still the pressure for cheap and hasty construction, the dangers attending ex-

posures to hunger, cold, and hostile savages drove the line along the overland wagon road, and away from the river canyons and river grades, and now, only the engineer is blamed for the mistakes of his employers. I beseech you in all your practice, do not permit the selfish wishes of employers to allow you to slight your own work. Do not do "cheap" work. Do not as you value your future reputations, permit yourself to enter into competition for employment which involves slighting your work or leaves a monument behind you which may be quoted as an example of ignorance, incapacity, or rascality. Insist upon taking a stand above that of the old-time "county surveyor" and though you do his work, insist upon exercising your talents, as engineers, rather than as laborers at so much per day. In employment in positions of trust, as dealing with titles, clients disposed to take unfair and fraudulent advantages of others, should understand that they should look for men to do their dirty work outside of the members of our society. Let us carry into our professional relations with the public a full realization of the dignity of our profession and refuse to debase it, to the mere level of a bread-winning trade.

In taking leave of you in my official capacity, I wish again to assure you of my full appreciation of the honor you have conferred upon me. I beseech you not to measure that appreciation by my attendance to the duties of the president, and believe me, that the prosperity of Montana, the profession and the society is my dearest wish.

THE LAGUN SAL DEL REY, OR THE KING OF SALT LAKES.

By Geo. W. Waite, Member Western Society of Engineers.

[Read March 2, 1892].

While locating the New York, Texas and Mexican Railway in the spring of 1882 from Victoria to Brownsville, Texas (some 325 miles), for Count Joseph Telfener and his brother-in-law John Mackey of California, I received instructions, at Santa Rosa Ranch, to make a thorough examination of the great Salt Lake, situated some ten miles west of the line of survey.

With my Mexican guide and a few of my party I started early in the morning with teams, but had no roads, and soon reached the Lake to the west edge of the Chaparral belt that we were in. We found it to be in a basin with no apparent inlet and only an outlet at high water. At that time the Lake was very low, about one mile in diameter and nearly round; surrounded by small hills covered with scrub oaks and other kinds of shrubbery. The hills were from twen-

ty-five to fifty feet high. When the Lake rose about six feet, it would overflow towards the south-east into the tributaries of the Rio Grande River; and our guide said at such times, cattle would drink the water a few hundred feet down the outlet, but only when the water was at its highest stage, and then only for a few days. All the surplus water has to come from the clouds.

The Lake, as we found it, had a sand beach from one hundred to two hundred feet wide, and the surface under the water was covered with a layer of crystallized salt, beginning at nearly nothing in thickness at the edge, and increasing to the centre, where it was about seven inches thick; and the water over the salt floor increased very slowly in depth from the edge towards the centre, where it was only from six to eight inches deep.

We tried at first to go in bare-footed, but only succeeded in getting in about two hundred feet from shore, when the sharp crystals cut our feet so that we had to return; then we tried to go in, in our stocking feet, but we only got some one hundred feet farther, when we had to return the second time, for our boots, on account of the crystals still hurting our feet through our socks. The first one hundred feet would not quite bear us, but after that we had no difficulty in reaching the centre. The heaviest loaded teams can drive through the Lake anywhere without danger. Where the crust next to the edge will not hold up, the sand is so solid, that it will hold up the heaviest load. When about half way to the centre we commenced to cut holes through the crust and take frequent soundings. We found substantially the following results: First, some four to eight inches of water on top, then from five to seven inches of salt; then about one foot of black decayed vegetable mould, the odor from which was *very* offensive. Next, a second layer of salt from two to three inches thick; then another layer of soft material similar to the first, and about the same thickness; then a third layer of salt from one to two inches thick, and lastly from three to four more feet in depth of the same black material, but not quite so offensive to the smell as the first layer, under the top crust of salt. Under all this, the iron rod struck something as hard as rock, and we were of the opinion that the Lake lay on a bed of quarry rock salt, as all the soundings struck this same hard bottom at about the same depth. We found men with oxen and very large carts, with the necessary implements, cutting the salt in to cakes and hauling them out on to the water, and after moving through the water, all the black slush would wash off clean, leaving the salt apparently pure, without a speck of impurities mixed with it. They were hauling it to Brownsville, some fifty miles south-east, and selling it at a good price, on account of the quality. One singular fact about this Lake is that in a few months, the hole will fill

again to the same thickness, thus making the supply perpetual.

The warning signals to teams, placed in the open space do not have to remain but a short time, as the crystallization will become sufficiently thick to bear the heaviest load.

During the rebellion, when the seaports were blockaded and the salt-works on Padre Island were closed, the people of Texas not only supplied themselves with salt from this Lake but it was sent to other states direct, and via Mexico.

No sign of a living thing was found in the Lake: but bones and deer horns were met with and some old logs, all of which were coated with salt crystals, above and below water, and fairly shone in the dazzling rays of the scorching sun, which was worse for the eyes than the brightest snow.

A kind of salt marsh grass grows all around the Lake, but at a respectful distance from the beach. The beach was as clean as a sea-beach, constantly washed by the ebb and flow of the tide.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

BOSTON SOCIETY OF CIVIL ENGINEERS.

DECEMBER 16, 1891.—A regular meeting was held at Rogers Building, Massachusetts Institute of Technology, Boston, at 19:40 o'clock. President Stearns in the chair. 47 members and 26 visitors present.

The record of the last meeting was read and approved.

Messrs. Frank L. Fales and Ernest W. Clarke were elected members of the Society.

The sum of $50 was appropriated for subscriptions to periodicals, binding and other expenses of the library.

On motion of Mr. Spalding, a vote of thanks was passed to the Philadelphia & Reading Coal & Iron Co., and to the Boston Tow Boat Co., for courtesies extended to the members of the Society on the occasion of the visit to the Mystic Wharves.

Mr. Doane for the committee to prepare a memoir of Samuel M. Felton, an honorary member of the Society, submitted its report. Mr. Doane gave a brief outline of Mr. Felton's life and spoke particularly of his early associations with him. A fine steel portrait of Mr. Felton was also presented by the committee, with the recommendation that it be suitably framed.

Mr. Doane for the committee on Permanent Quarters reported progress.

Mr. H. H. Carter read the paper of the evening entitled "Stony Brook and its Improvements." The paper was illustrated by a large number of lantern views and working drawings.

After a short discussion of the paper by the President and Messrs. FitzGerald and Smith, the Society adjourned.

S. E. TINKHAM, Secretary.

JANUARY 18, 1892. A regular meeting was held at Young's Hotel, Boston, at 19:45 o'clock. President Stearns in the chair. Eighty-four members and fifteen visitors present.

At the suggestion of the President, the by-law prescribing the order of business was suspended and the question of choosing a committee to nominate officers was taken up. The following members were elected upon nominations from the floor, to retire and report a committee of five to nominate officers for the ensuing year: C. F. Allen, F. W. Hodgdon, H. H. Carter, Albert H. Howland and A. F. Noyes. Later in the meeting this committee reported the following as a nominating committee and they were unanimously elected. Desmond FitzGerald, Dexter Brackett R. A. Hale, G. T. Sampson and H. D. Woods.

The record of the last meeting was read and approved.

Messrs. Bert A. Parlin and Winslow L. Webber, were elected to membership.

The President announced the death of Charles W. Drake and Sophus

Haagensen members of the Society, and on motion, the President was requested to appoint committees to prepare memoirs. The President named as these committees, Messrs. H. B. Wood and E. S. Dorr on memoir of Mr. Drake; and Messrs. L. Bradford and T. T. H. Harwood on memoir of Mr. Haagensen.

It was voted to have the usual annual dinner and Mr. Henry Manley was appointed a committee with full powers to make the necessary arrangements.

President opened the discussion of the evening upon, "Municipal Government," by calling attention to one of the most important of its functions, the construction and maintenance of the great public works of a city, and gave the amounts expended in Boston for public works and for all other purposes, showing that for the year 1890-91, the former was fully one-half of the total expenditures.

He then introduced Mr. Robert Moore, of St. Louis. Chief Engineer of the Merchants Terminal Railway of St. Louis and formerly a member of the Board of Public Improvements of that city. Mr. Moore read a very interesting paper entitled, "Municipal Engineering in St. Louis."

Short papers giving the outlines of the form of municipal government in several larger cities of the country were presented as follows:

Boston, by William Jackson, City Engineer.

New York, by Francis M. Scott, Aqueduct Commissioner.

Providence, by J. Herbert Shedd, City Engineer.

Philadelphia, by Prof. Dwight Porter.

Buffalo, by E. B. Guthrie, Deputy City Engineer.

Paris, France, by H. D. Woods, C. E.

Owing to the lateness of the hour and to afford an opportunity for discussion, the last two papers were not read.

The remainder of the meeting was devoted to a discussion of the several papers, but more especially to that on St. Louis. Mr. Moore very kindly answering numerous questions, with regard to the working of the government of that city.

At the conclusion of the discussion, Mr. FitzGerald moved a vote of thanks to Mr. Moore for the very valuable paper which he had read and an expression of our appreciation of the trouble he had taken in coming so far to deliver the paper in person before the Society. The motion was unanimously carried.

On motion of Mr. Howe a vote of thanks was also passed to Mr. Scott, Mr. Shedd and Mr. Guthrie, for the papers which they had prepared.

Adjourned. S. E. Tinkham, Secretary.

WESTERN SOCIETY OF ENGINEERS.

January 6, 1892. Annual Meeting:—The 287th, and Annual Meeting of the Society was held at the Sherman House, January 6, 1892, with some 110 members and guests present. President L. E. Cooley in the chair. The meeting was called to order later than the programme indicated, due to delay caused in working out the final details of the annual election of officers under the new By-laws.

The minutes of the preceding meeting were approved, and the Secretary then presented his report for 1891.

The following names of applicants for membership in the Society

were received: L. D. May, F. C. Williams, Jr., Wilson M. Vinyard, Melville Brown, F. A. Macdonald, R. H. Bethel, L. H. Evans, Richard D. Gottlieb, Carlton R. Dart, Vibe C. Spicer, Wilmer W. Salmon, Jas. S. Robinson, Henry M. Sperry, Joseph I. Kelley, Albert W. Smith, John W. Clarke, Geo. M. Walker, Sam'l M. Rowe, Edwin Duryea, Wm. A. Parker. Mr. S. S. Greeley resumed membership.

MR. L. P. MOREHOUSE:—The Secretary made mention of the fact that Col. Mason, the first president of the Society, had died within a few days. If this is the proper time, I would say that it seems to me that some action on the part of the Society would be proper under the circumstances. A committee might be appointed for the purpose of drawing up a suitable resolution.

Col. Mason was not largely known, I suppose, to the younger members of the Society, but all of the older men knew him very well. For many years he was a very prominent man in the city of Chicago, and before that time in the engineering profession in the West. He came to Illinois in 1851 as chief engineer of the Illinois Central Railroad Company. That was his principal engineering work in the West, although he was subsequently connected with many important enterprises. He was, I think the consulting engineer for the deepening of the Illinois Canal some twenty years ago. In New England he was well known as an engineer before he came to the West, and altogether his name is one that the profession may be proud of. His career has been honorable in every particular. Wherever he has been known he has been respected as a man and as an engineer. He was the first president of this Society, also one of its organizers, and always a valuable member. I would move that a committee of three be appointed to draft a suitable memorial in regard to Col. Mason.

The motion, seconded by Mr. Geo. S. Morison, was put to vote and unanimously carried.

THE PRESIDENT:—I think it would be appropriate at this time particularly, to hear from the committee on the International Engineering Congress for '93, a subject that is pretty large, and very properly can be brought up at a meeting of this kind. I would call upon Mr. Chanute to inform the members of the Society what the status of the movement is.

MR. O. CHANUTE:—There is but little to report. The committee is now endeavoring to organize the distribution of the work provided for the International Congress. It is proposed that that Congress shall be divided into appropriate sections, as it is believed that it will be too large, too bulky and too cumbersome to hold its sessions as a single body; it is therefore proposed that after the first joint session, at which addresses of welcome shall be made, the Congress shall be divided into certain sectsons consisting of one for Civil Engineering, a second of Mechanical Engineering, the third representing Mining Engineering, the fourth Metallurgical Engineering, the fifth Electrical Engineering, the sixth Military Engineering, and the seventh Marine and Naval Engineering. That each of those sections shall be organized in advance by the national Society corresponding thereto, or by that department of the government which corresponds with the military engineering, or with the naval or marine engineering; that each of those organizations shall appoint in advance the chairmen, the vice-chairmen, the secretaries and the advisory councils who are to act in such capacities, shall endeavor to secure the attendance of the leading engineers of the world in each of thos

departments, and shall arrange for an order of exercises, which is proposed to consist of two classes; first, the discussion of subjects to be selected by the advisory council in advance which possess general interest for all engineers, pertaining to that branch of the profession, and secondly, the reading and discussion of voluntary papers. In order to promote the discussion of any subject it will be necessary to prepare in advance some digest or synopsis of that subject,—a statement of the condition of the art, as it were, so as to have a basis for discussions, and it will be necessary also to provide in advance for some expert on each subject in order to make sure that the discussion shall be instructive and well directed. There is therefore, as you will perceive from this rough programme, a great deal to do, a great deal to accomplish, and it will be necessary for all engineers to aid, so far as they can, in forwarding the work of the committee. You probably know that an organization called the Auxiliary of the Columbian Exposition has been formed for the purpose of promoting this Congress, and that it has appointed a general committee of management for the Engineering Congress, and also an advisory council. An engineering committee chiefly consisting of the gentlemen who have already been appointed as the Executive of the joint engineering societies, the principal engineering societies of this country, have formed an organization through which they propose to accomplish two things: first, to promote the engineering congress in a general way, and secondly, to maintain during the entire time of the Exposition here, a headquarters for the receiving and entertainment of all engineers, both foreign and American, who may come here to visit the Exposition. In addition to that it will probably be necessary to make arrangements for the purpose of guiding foreign engineers through the Exposition, showing them the various things they may desire to see, and furnishing them information. These are, so far as I know, the present plans, present status and present prospects of this Engineering Congress and proposed Headquarters, and I would say that the sum of $15,000 is now being raised among the engineers of the country in order to defray the expenses.

The President directed the attention of the Society to the necessity of looking into the question of quarters, the lease of the present rooms expiring on May 1, and called for action.

It was moved and seconded that the committee on Permanent Quarters be directed to consider the matter and report to the Society.

The resolution of Mr. C. T. Purdy, presented at the December meeting, in the matter of steel and iron structural material in the new system of tall buildings, was again laid over, by consent, until more time could be given the subject.

The following motion presented by Mr. Geo. S. Morison was seconded and carried:

That a list of the members of the Society, and also a copy of the Constitution and By-laws, be published and distributed among members during the present month.

Mr. O. Chanute:—Before the meeting adjourns I wish to submit a resolution. The committee on Bridge Legislation found itself compelled to give some annoyance to the gentlemen in possession of the information which they sought, and I think they ought to be thanked. I therefore beg to offer this resolution:

Whereas, Much of the value of Report of the Committee on Bridge Legislation, recently made to this Society, is due to the information con-

cerning the practice of other countries and states, gathered by the committee, therefore:

Resolved. That the thanks of this Society be tendered to Mr. James Forrest, of London, to Mr. T. Seyrig, and Mr. E. Pontzen, of Paris, and to Mr. Geo. C. Crocker, of Boston, Mass., who furnished this information, and that the secretary be instructed to send to each of those gentlemen a copy of this resolution.

The resolution was seconded and carried unanimously.

PRESIDENT COOLEY.—In this connection I would say, I think it would be proper, unless there is some business not now known, to have the subject of Bridge Legislation made the special order for the next meeting.

PRESIDENT COOLEY'S ADDRESS.

I note that the programme puts down the retiring president for an address. At the beginning of this term he escaped making an address on the general plea that it was not required of a man to buckle on his armor, and now that he is about to put it off, he does not feel the obligation. The fact is, the president does not intend to make an address for this evening, for the very good reason that he has not had time and opportunity. He has had very grave measures of state weighing on his mind for some time, and the strain entailed leaves him neither in condition or mood to prepare an address. I wish, however, to congratulate the Society on the progress made during the last two years, on the growth that we have attained and on the excellent character of the membership and especially the new membership which has come into the Society. The Society is getting to be strong, and we have taken up a class of subjects which have interested the public and have been of utility in considering matters connected with the good fortune of this community and of this Society and I am thoroughly in sympathy with that view. Perhaps we have worked out that lead to a certain extent, and may have to take a new tack, for the next year, and for that we all wish to have a new man at the helm. There are some questions coming before the Society in the immediate future which seem to me to be important. We have reached a stage of growth where we have got to go one way or the other. We have got to take upon ourselves either larger proportions, or perhaps smaller proportions, and there are certain questions which are, likely to come up in the next year in connection with the future of the Society, in connection with the provisions which must be made to maintain its progress and development and influence, and in connection with the responsibility and dignity which it should assume in connection with this World's Fair, which will require the very gravest consideration —will require a great deal of energy, and be associated with all the enthusiasm which you can inject into your pocket-books.

If I had been disposed or been able to make a longer address this year, I should have devoted my attention in the line of the address which I made last year, which dealt largely with the ideal state which engineering might hope sometime to attain. It is a good deal like our religious thought; sometimes we set an ideal which we never attain until the millenium, but it is a good thing to have these ideals, in order that we may aim for them. So I set a gauge for engineers at that time which I do not expect will be attained until the millenium. During the past year I have had occasion to do a great deal of thinking, and under circumstances which made a man think, and those thoughts have come to me a second time, and if I were disposed to make an address or write one, it would be wholly upon the subject of technical education, not upon technical education as now given in our schools, which is good and proper, but upon the

idea that technical education should be spread throughout the generations of men, as you might say, as a basis for business and for thinking, and the status of every engineer in every community will be vastly improved when his constituency is composed of men who can appreciate how and what an engineer thinks. I have no doubt that in this country where the people are supreme— where the people very properly do everything, that when it comes to the matter of public works, that we spend at least 50 per cent. more than is necessary, and do a vast number of things unwisely that we would not do if the constituency generally was properly educated and the functions of engineering, as an art and as a science, were better appreciated.

Then I should look upon the question of technical education also in another view, as something that is in harmony with the spirit and progress of our age, as something that is to be in no sense a bread and butter education, but is in the highest degree a culture. There is a good deal that can be said in that direction as against the old school methods of education, which, if I devoted time to it, I think I could say in very good shape: I will not attempt to do it so extemporaneously.

And that brings me along to this point, we have not in Chicago or in the vicinity of Chicago, a proper school for technical education. We have many and grand schools throughout the country, but not enough of them.

This city has become the second manufacturing city in the Union and is in position, perhaps more than any other city, to support and to furnish facilities for students in that line, and I think the Society should interest itself in this matter. We have institutions of learning in the vicinity of Chicago, some very good ones, and we have a very great one that is proposed and furnished with a large endowment. I think it is a matter that the Society may very properly consider, as to whether it cannot—as to whether it should not—in some way or other have some influence in agitating this matter, and bringing about something in that direction, which will be an honor and credit to our city and to our Society and to everybody who may be connected with it. That is the general thought which I wish to bring out.

In regard to the Society itself, so far as I have been instrumental in advising in regard to its policy, I have been looking forward to the day when the Society should have some available revenue aside from that necessary to maintain a sort of an eleemosynary existence—a sort of hand to mouth existence. The last three or four years we have anticipated the revenue to a certain extent and up to this time we have made no mistake by doing so, but as our dues are now fixed, as the policy of the Society is now fixed, it is not possible to hope for the attainment of a surplus revenue, or such a revenue as will enable money to be applied to the work of committees, and to the work which the Society may properly do. We have useful men in the Society, very useful men, some four hundred of them, and all of them are willing to serve on committees: many of them can give expert advice, equal to that of any one in the country, in regard to the subjects which may be referred to them, but none of them are in position to give weeks of time voluntarily to committee work.

If the Society was in shape so that it could employ a secretary, or employ some man to do the actual work, the drudgery of committees, the amount of work which the Society could do, and the amount of influence it could command for the good of the profession and the public could be multiplied manifold. That is a subject which I think you can think about.

There is another matter also upon which the Society has taken some action in the past and in which some of the members have taken a great deal of labor upon themselves, and that is the idea that sooner or later in this country there will be a federation of all the Society interests in the land. I think everybody appreciates the desirability of such a plan as that, and that the sentiment is ripe for it, but up to this time nobody has been able to propose a working plan for such an object, but I think the time will come, and come perhaps sooner than some of us anticipate.

Now gentlemen, my successor is not here—it is part of the programme that he should take possession of the office very soon—in fact, as soon as I get through talking, and I will only say in conclusion that I thank you most fully and heartily for the honor which you have done me in making me your president for the last two years, and for the consideration which you have shown me in the discharge of my duties, and I only hope that I have deserved in some manner the confidence and the enthusiasm and unanimity with which you have elected me to that office. I thank you gentlemen.

A recess of fifteen minutes was here taken to wait the report of the judges of election.

The Society was again called to order and the following report was presented:

The undersigned judges of election having performed the duties assigned to them report as follows:

For President—total number of votes 206; necessary for a choice 104: L. P. Morehouse, 22; Isham Randolph, 100; John F. Wallace, 84.

For First Vice-President—total number of votes 203; necessary for a choice 102: E. C. Carter, 134; H. E. Horton, 68; John F. Wallace, 1.

For Second Vice-President—total number of votes 201; necessary for a choice 102: Ira O. Baker, 152; Chas. Hansel, 49.

For Secretary, Treasurer and Librarian—total number of votes 206; necessary for a choice, 104: John Lundie, 52; J. W. Weston, 154.

For Trustee—total number of votes 201; necessary for a choice 101: H. B. Herr, 88; C. L. Strobel, 113.

(Signed) Thomas Appleton, Fremont Hill, J. C. Des Granges.

Considerable discussion ensued upon the fact that the voting by the rules, had failed to elect a President, and finally Mr. Benezette Williams presented the following motion, which was carried:

That the Board of Directors be directed to call an election for president in the manner provided by the By-Law pertaining to election of officers.

An adjournment was then taken to the banquet-room, where after due time had been spent in disposing of the "Menu" the Society was again called to order by President Cooley, who introduced as the first speaker of the evening, Mr. L. P. Morehouse.

Mr. Morehouse referred to the summary manner in which he had been made a speaker, and also gave the reason for declining the nomination for president. He was after a more lucrative office—that of alderman. In a very amusing manner he treated of the platform which he intended to present to his constituency, involving much engineering "estimate" in relation to the future of the Chicago river, and having taken the Society into his confidence he trusted they would all vote for him.

The Rev. Conrad Haney, then delivered an address on "The Civil Engineer" which will be found on another page.

Mr. Willard A. Smith, Chief of the Department of Transportation, World's Fair, followed:

I have felt very proud as I sat here to-night and recognized for the first time the full significance of the work of the civil engineer, that I am a member of this Society. The words of the last speaker have filled me very full of pride. I was a member of this association in the days when Mr. Morehouse struggled hard to keep it alive. There was nothing in the nature of a coolness, as I recollect; it was more in the shape of dampness, —something in the shape of accumulated dews (dues). Of late, however, I have been very proud to resume that membership. I shall be very glad to make the acquaintance of the individual members more than I have.

Now that I am called upon to speak to you to-night without text or pretext—I felt sure that some subject would be assigned me and I therefore feel somewhat embarassed. I inquired what I was expected to speak about and was told, about three minutes,—that was the only satisfaction which I have received. I am not sure but the proper thing for me to do would be to fall back upon what the esteemed "Tribune" would call "Cooley's Tactics" and ask for more time. I have not any mercy on your honorable President. The last time I met him socially he seriously wounded my pride. I was complaining that a certain reporter of some paper had called me in an item "General Smith," and with his characteristic habit of always apologizing for the press, Mr. Cooley answered, "Well you know, Smith is a very general name."

In the absence of any special topic my mind has wandered on many things. I thought it would be quite proper to pronounce some eulogy on the engineering profession, but after what we have just heard, what is left for me? I take some comfort, however, in thinking that the whole thing will round up all right. A very doting parent once said to a friend "Sometimes the confidence, the absolute confidence which my little son has in my knowledge and wisdom fairly makes me dumb." The friend says: "Oh, I wouldn't worry about that: when he gets to be 20 years old he will think you don't know any thing, so it will average up all right." So I think the speakers of the evening will average up all right.

The subject that comes to me from 20 years' experience, is the press, and I was a little fearful that that might be the toast that I should be called upon to respond to. There are a number of different kinds of presses—cotton presses; presses of a fair lady's form in what the printers call the embrace; there is the hydraulic press with which the engineers are familiar, and there is the press which draws its inspiration, not so much from water as from the bottle—of ink. I am sure that you will all agree with me in eulogizing the press as one of the mighty engines of the day, unless it is perhaps your honored president. The press is the daily encyclopedia of all wisdom and knowledge, the ultima thule beyond which we are to look for nothing; it is the instructor of engineers on drainage problems and other similar features. But my own connection with the press has been a sort of one-sided one, a sort of brother-in-law. I have been connected with a technical paper and during that time my experience has brought me so closely to the engineer that I almost felt that I was an engineer. I remember an editor who was once called to the witness stand, and the lawyer wanted to know if he was an engineer. "Yes sir, I am an engineer." "Are you a mechanical engineer?" "Yes sir." "Did you ever take a course in engineering?" "No." "What made you an engineer?" "Oh," he says, "I have written so much on the subject that I have

sort of absorbed it, and I think I am engineer." So if I am an engineer I became one by absorption. I do not know that you recognize that course of training. The engineer is the typical man of the 19th century. In him the very spirit of the age finds its fullest expression. The French have coined a phrase into an adjective which is a very expressive one and which they are now using in connection with everything that is progressive, "le but du siecle" they say, that is, the end of the century. The engineer is the end of the century man; he is the man who is leading at the close of this 19th century; he will project himself ahead into the century that is to come. And this brings me very naturally to the theme which is upon all our minds in the beginning of this last decade of the 19th. century, that final blaze of glory which shall illuminate the close of the century and extend far beyond, the World's Columbian Exposition.

It is my privilege to be connected with that exposition in the capacity of Chief of the Department of Transportation Exhibits, not of Transportation, as your president has announced. That has brought me very closely again in connection with the engineering fraternity. In the discussions which have been had in connection with the World's Exposition was one as to the exhibition which should be made by the engineers. It was proposed at one time that there should be a large collection of engineering models of all kinds. The magnitude of the thing, I think, was the reason why it has not gone through. Possibly there was another reason. The World's Fair is divided naturally into departments. Into what department of the World's Fair can you go in which the science of engineering does not play an important and vital part? If you take up the study of ethnology, you will find much of the engineer there: if you come to the liberal arts, engineering is itself a liberal art; if you come to the department of manufactures what would it be without engineering in its different branches! So if you go to the Department of Agriculture so if you go to the Department of Machinery; so if you go to the Department of Fish and Fisheries, and even in the Department of Art itself, but finding its fullest exhibition in the Department of Transportation. Transportation is the distinctive science of the 19th century; it is the one thing among all others that distinguishes this century from all others. Preceding centuries have made their mark in religion, in philosophy and in letters, but it has remained for the 19th century to open the highways and the by-ways of the world by the modern science of transportation, to offer highway to all things good and all things broad, and scatter the light of modern civilization to the darkest portion of the earth. Therefore I say, in our department of transportation exhibits, including all departments of exhibits, whether used upon the land or in the sea or in the air, or in all other forms, the science of engineering shall find its highest exposition at the Columbian Exposition. Gentlemen, I ask for this department your kindly consideration and co-operation, and it is in your power to render it of much interest; it is in your power to give us many valuable suggestions; it is in your power to criticise in a friendly character: we get a great deal of criticism of the other kind, which often reminds me of the story of the man who was walking by a taxidermist's shop and saw an owl in the window; he looked at it and said,—"Who ever saw an owl standing in such a position? who ever saw an owl holding his head in that way? Who ever saw an owl with feathers in that way?" And just as he was about to turn away in disgust the owl changed to the other foot That is the character of most of the criticism, I am sorry to say, which we are obliged to

meet with in any great work. You engineers know how that is. Gentlemen, I am mindful of the limit of time at my command, and I am afraid if I trespass the President is likely to work in that Skokie cut-off on me.

Mr. Randolph briefly referred to the result of the election and his own efforts had he have been elected. Expressing a word of eulogy on Col. R. B. Mason, and referring to the eloquent address of Mr. Haney he closed with thanks to the Society.

Col. R. O'S Burke expressed his pleasures at the discourses of the evening, warmly eulogising the speech of Rev. Mr. Haney, and suggested going a little further on. He said: "Let us take this period that he refers to, that we may class as a series of ages that have terminated in disgrace and disorder and the clash of wars; let us look beyond that and leap over a series of years into the future and travel, if you wish, with some stray citizen of the years to come. Travel with him over the ruins of the present day, noticing at the time the evidence existing of the achievements of present science, but passing over these ruins, pause if you will at a monument with the crumbling associations of ages around it, yet still retaining marked lines of strength and form. Brushing away the dust of ages, we will read on its face: "Erected to the one great curiosity of the 19th century, the politician who was found capable of doing justice to the engineering profession." Pass on a little further, we will find another monument: brush from that also the evidence of the ages, clean the face of it and strive to deciper the characters imprinted thereon, and we will see, "Erected to commemorate the conclusion of the Chicago elevated-railroads in the year 3472." Pass on a little further and you will discern yet another monument; pause if you wish,—treat it with the same care and tenderness, because age demands that consideration from your hands; read also the legend on that: "Erected to commemorate the conclusion of the Chicago Sanitary Drainage Enterprise in the year 4766." And so on, the people of the ages will wander, glance over these monuments and entertain for us, as we do now, for those who have been so splendidly painted by the speaker of this evening,—profound regard for the engineers of this period, who, in spite of lack of feeling, or support, face to face with the evidence of lack of sympathy, doubt, and appreciation, ten thousand conflicting agencies that to a certain extent make in road upon the profession,—as I said, the critics of the profession of that period will be ready to do us justice and wonder that even these enterprises were finished at all, after all the opposition that had been presented against them.

Col. Burke closed his remarks by alluding to the speech of Mr. Morehouse, and the figures it contained, and told the story of the Irishman and his little pig, which ate two buckets full of food but did not after the feast more than half fill the pail himself. The story convulsed the assemblage.

The speaker closed by referring to the needs of the profession "We ought to have an Engineers' Building in this city; we ought to have a complete, thorough co-operation between all the members of the profession, from one end of the United States to the other, for the protection of professional honor, professional privileges, professional prosperity and professional happiness."

After the recitation of a poem by Mr. W. J. Karner, the meeting adjourned.

John W. Weston, Secretary.

ENGINEERS' CLUB OF MINNEAPOLIS.

THURSDAY, JAN. 7TH, 1892.—The annual meeting was held at the Public Library, President Pike in the chair.

Minutes of the preceding meeting were read and approved.

Mr. Pardee's bill on account of experiments on efflorescence on brick was ordered paid.

It was voted that a committee of three be appointed to provide for the next joint meeting with the St. Paul Club, to be held in Minneapolis Feb. 4th.

The chair appointed Messrs. Nexsen, Huntress and Cappelen.

The secretary then read his report as follows:—

To the President and Members of the Engineer's Club of Minneapolis.

According to the constitution I beg to report as follows:—

The finances of the club are in good condition according to the following figures.

RECEIPTS.

Cash on hand Jan. 14th 1891	$ 26.78
Cash by assessments	181.00
Cash by individual assessments on account of Journal for 1890	6.00
Total	$ 213.78

EXPENDITURES.

Stationery	$ 14.60
To Association Journal	80.14
Engineering News to June 1892	5.00
Engineering & Building Record to June. 1892	4.00
Engineering Congress at World's Fair Chicago	36.00
To entertaining the St. Paul Club	63.50
To Reports etc	1.15
Stamps etc	5.45
Total Expenditures	$ 209.84
Cash on hand	3.94
Total	$ 213.78
Taking the cash on hand	$ 3.94
Dues yet to be collected	23.00
Total assets	$ 26.94

Three members were dropped from the rolls for non-payment of dues, one member resigned.

One new member was elected and qualified, one member elected but has not yet qualified.

Total resident members	25
Total-non resident members	3
Total	28

I think it fair to state that the club has been more prosperous during the last year than for several years previous and for this, much is due to our President, Prof. Pike, who, together with President Mason of the St. Paul Society, inaugurated a series of joint meetings between the two clubs.

We have, all told, had five joint meetings, 3 in St. Paul and two in Minneapolis, at which meetings a better grade of papers than usual has been presented, at least, as far as the Minneapolis Club is concerned.

Papers read at these meetings were by the following Minneapolis gentlemen, viz:—

The History of the Minneapolis sewerage, by Mr. W. D. VanDuzee.

The late Suspension Bridge of Minneapolis, by Mr. F. W. Cappelen.

Geodetic Leveling, by Prof. W. R. Hoag.

And by the following St. Paul gentlemen viz:—

On Bricks, by Mr. Rundlette.

On Railroad Tunneling, by Mr. Woodman.

The attendance at these meetings was considerably greater than at others, and the social intercourse resulting between members of the two clubs can but be of benefit generally.

Two special meetings were called to discuss, finances, entertainments etc.

At the special meeting held May 12th '91 the club took quite an important step in so far that the Association Journal was ordered for 26 members. The club had in 1890 practically lost its connection with the Association and it was really a matter of courtesy of the Board of Managers, not to drop us all together. The Journal is a too important link between the different clubs and their members throughout the country, to be neglected on account of an expense of hardly $3.00 per annum per member in good standing.

At other regular meetings papers were read by:

Mr. Olaf Hoff on Bridge Erection.

Prof. Pike on Leede's gas apparatus for burning petroleum as fuel.

Mr. Elbert Nexsen on Railway construction in Peru, S. A. on the Callao, Lima & Oroya R'y.

The club has also taken proper and active part in the matter pertaining to the Engineering Congress to be held at the World's Fair in Chicago and has already paid one-half of its assessment to defray the expenses of said congress. Probably too much can not be said about the benefits that may accrue to the club from that source.

I beg to ask the members to take as much active part in the deliberations of the club as possible and lighten the work of the officers by voluntarily contributing to the literary entertainments of the meetings, notifying the secretary a little in advance of the meeting.

I also beg to call the members attention to the fact that from now on the only day open for our meetings will be the first Thursday of each month.

Respectfully submitted,

F. W. Cappelen, Sec'y & Treasurer.

The report was adopted and placed on file.

Mr. Abbott was appointed auditor.

The following gentlemen were elected officers for the ensuing year.

Wm. A. Pike, President.

W. W. Redfield, Vice-President.

F. W. Cappelen, Sec. & Treas.

A. B. Coe, Librarian.

Elbert Nexsen member of Board of Managers of Engineering societies.

The librarian was instructed to make out a list of journals, periodicals etc., needed to complete the library.

An assessment of four (4) dollars was ordered.

It was voted to pay the janitor, Mr. Runge, ten (10) dollars for services rendered.

Mr. Hoff moved that the chair appoint a committee of two to furnish a list of engineering books, books of reference & periodicals in both English and foreign languages and report to the club. with the object in view of requesting the Library Board of the City of Minneapolis to buy such books and subscribe for such periodicals as were not already in the Public Library. Carried Mr. Hoff and Mr. Cappelen were appointed as such committee.

The secretary was instructed to notify all members in regard to this motion with a request to each member to send in a list of such publications as he might desire to have purchased.

Adjourned. F. W. CAPPELEN, Sec'y.

MONTANA SOCIETY OF CIVIL ENGINEERS.

JANUARY 9, 1892.—The Annual Meeting of the Society was held at the office of Messrs. Sizer and Keerl.

The meeting was called to order at 3:30 p. m., by President Wilson.

The following members were present:—Messrs, Wilson, (Chairman), McRae, Sizer, Pearis, Darling, Harper, Haven, Cumming, Jones, Knight, Keerl, Foss, Wheeler, Herron, Hovey, Goodale, Bundock and Deutsch.

The Secretary read the minutes of the last meeting which were unanimously approved.

Mr. Keerl read an application for admission to the Society from J. P. Gutelius of Butte, Montana, which set forth that gentleman's qualifications and was endorsed by Messrs. Knight, Wilson and Harper. Mr. Gutelius was present at the meeting and on motion of Mr. Sizer he was invited to attend the banquet at the Helena Hotel in the evening.

Secretary J. S. Keerl then read his report for the past year. The membership numbers 59 active, and three associate members, one member, Robert J. Walker, having been removed by death during the year. The report was adopted as read, and referred to the Board of Trustees for action.

Mr. A. S. Hovey presented his report as Treasurer, which showed the receipts during the year to have been $580.03 and the expenditures $450.32, leaving a balance in the hand of the Treasurer of $129.71. This report was also referred to the Board of Trustees for action.

The election of officers then followed, Messrs Foss and Hovey being appointed by the Chair to act as tellers. The following were elected:

President, Col. W. W. de Lacey.

First Vice-President, A. B. Knight.

Second Vice-President, J. S. Keerl.

Secretary and Librarian, F. D. Jones.

Treasurer, Albert S. Hovey.

Trustee, for three years, E. H. Wilson.

Mr. Wilson, the retiring president, delivered an address on vacating the chair, which is given in the body of the JOURNAL.

Mr. A. B. Knight in the absence of President de Lacey then took the chair, and Mr, F. D. Jones assumed the position of Secretary in the place of Mr. J. S. Keerl.

Correspondence was presented from the General Committtee of Engi-

neering Societies at the World's Fair asking that the Montana Society should take steps to raise $120, its pro rata share of $15,000 required to meet the expenses to be incurred by the Engineering Societies at the Exposition. Mr. Keerl explained that already $50 had been appropriated out of the General Fund for this purpose and the question was whether an extra assessment of $2.00 per capita be levied on the Members of the Montana Society, or the whole sum $120 be made up from the general fund. He set forth the specific advantages offered members of the Society at the Exposition, and moved "That an assessment of $2 00 per member be made and the amount raised applied to this fund."

Mr Haven offered an amendment as follows: "That this amount be appropriated out of the general fund and then an assessment be made to cover this amount."

Mr. Herron moved as a second amendment "That an assessment of $2.00 be made, as moved by Mr. Keerl, and then if the amount called for from this Society be not paid by June 30, 1892, that the deficit be made up from the general fund." Mr. Sizer seconded the amendment of Mr. Herron and it was carried.

Mr. Keerl:—"We have a member in Chicago, Mr. F. A. Ross, and it occured to some of us, that if Mr. Wilson thought well of it, the Society should name Mr. Ross as his alternate on the general committee of Engineering Societies at the World's Fair. He moved "That Mr. Ross be named as Mr. Wilson's alternate on this Committee." Seconded by Mr. Wilson and carried.

Mr. Foss, Chairman of the Special Committee on public land surveys then read Senator Power's letter to the Secretary a second time which embodied the main features of his Senate Bill No. 663 looking for a more accurate representation of the topographical features of the country in Government land surveys, and submitted a report, which on motion of Mr. Haven was adopted.

Mr. Sizer then moved that the present Committee continue in office with power to draw up recommendations and forward them to Senator Power. This was seconded by Mr. Wilson and carried.

Mr. Haven said that owing to press of business he had not been able to prepare a report as chairman of the Committee on State Engineer. Mr. Keerl thought there were hopes for the appointment of a State Engineer if proper efforts were made at the call of the next legislature, and he moved "That the same special committee on State Engineer be continued to consider the question of the creation of the office of State Engineer." Carried.

Mr. Keerl also moved "That the Committee appointed to draw up resolutions on the death of Robert J. Walker be instructed by the Secretary to forward the same to the relatives of Mr. Walker and file a copy with the Secretary of the Society." Carried.

Mr. McRae who had promised at the last meeting to prepare a paper proposing amendments in the present methods of running connection lines in mineral surveys stated that he had not had time to attend to the matter, but he suggested that if the Society would take the matter into their own hands and appoint a committee to show the absurdities of having separate connection lines, and send copy of same to the Commissioner of the General land office himself, personally, the orders now required by the Department might be materially improved. He moved "That a Committee of three be appointed to prepare a petition to the Commissioner

with regard to the absurdities of running connecting lines of mineral surveys." This was seconded by Mr. Foss and carried. The chairman appointed Mr. Keerl, Mr. Wilson and Mr. Wheeler as this committee.

On request of Mr. Keerl Mr. McRae promised to write a paper on the subject and submit it to the Society.

Mr. Herron moved "That our past President be requested to write out his address in full and furnish the Secretary with a copy for publication in the JOURNAL." Carried.

The Committee of arrangements for annual meeting were then called on to make their report. Mr. Herron said that all the arrangements had been made hurriedly as they had only been able to get a quorum together about a week ago, and asked the members to pass over any defects or faults in what was said and done. They would meet at the Helena Hotel at 7:30 P. M. and he hoped they would have an enjoyable time.

Mr. Foss moved "That Mr. Keerl be appointed manager of the Society on the Board of Managers of the Associated Societies, for the coming year." Carried.

The question arose what committees the President should name for the ensuing year and Mr. Foss moved "That such committees be: A committtee on Topics, a committee on Library and a committee on Na-Public Works." Carried.

Mr. Foss then moved that the society adjourn until 9:30 P. M. Carried.

9:30 AT THE BANQUET. Too much cannot be said in praise of the efficient work of the Committee of arrangements, the banquet was perfect. Mr. Keerl as Toast Master, introduced with much skill the following gentlemen who responded to the toasts opposite their names.

Mr. J. A. McKnight, The Press.

Mr. Haven, The Montana Society of Civil Engineers.

Mr. McRae, Mineral Land Surveys.

Mr. Goodale, Miners and Mining Engineers.

Mr. Rolph, Engineers and the Irrigation Convention.

Mr. Jones, The Public Land Surveys.

Mr. Deutsch, The Working Tools of the Engineer.

Mr. Gutelius, Electric Power.

Mr. Sizer, Sapphire and Ruby Fields of Montana.

Mr. Wilson, The Engineer at the World's Fair.

2 A. M. It was ordered that the Secretary inform Mr. E. H. Beckler of the Great Northern Railway and Mr. W. L. Darling of the Northern Pacific that a unanimous vote of thanks was tendered these gentlemen for the highly prized courtesies extended. The Secretary was also instructed to convey to Mr. Herron the Society's appreciation of his services, in carrying out all the arrangements of the annual meeting.

Resolved, That the hearty thanks ot the Society are due to the retiring officers, and especially to our retiring Secretary, Mr. J. S. Keerl.

FRANCIS D. JONES, Secretary.

THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

JANUARY 12, 1892. Club met at 8 o'clock p. m., with President Gobeille in the chair and forty-six members and visitors present. The minutes of the last meeting were read and approved. Messrs. Baker and Kelly were appointed tellers to canvass the ballots for new members.

The librarian announced the receipt of several books for the library. Mr. F. C. Osborn nominated Messrs. Mordecai, Blunt, Richardson, Kingsley and Bartol as a committee to nominate candidates for offi ers for the ensuing year. Messrs. Whitelaw and Warner were also nominated. All of the nominations were seconded. There being seven candidates and only five members of the committee it was voted that ballots be cast and that the five having the largest number of votes should constitute the committee. Messrs. Bowler and Culley were appointed tellers to canvass these ballots.

The tellers previously appointed reported that Mr. Charles W. Hopkinson had been elected an active member.

The tellers last appointed reported that ballots had been cast as follows:

Mr. Mordecai,	. . . . .	29 votes.
" Kingsley,	. . . . .	32 "
" Richardson,	. . . . .	33 "
" Warner,	. . . . .	27 "
" Whitelaw,	. . . . .	26 "
" Bartol,	. . . . .	23 "
" Blunt,	. . . . .	17 "

Messrs. Mordecai, Kingsley, Richardson, Whitelaw and Warner were therefore declared elected as members of the committee.

Prof. John N. Stockwell then read an interesting paper entiled: "On the Center of all the Dry Land on the Earth's Surface." Prof. Stockwell described the increasing wants of mankind as he advances in civilization, and noted some of the struggles that have taken place in his efforts to establish systems of weights and measures, and the most noted of all has been that to introduce the Metric System. Its opponents have made most elaborate researches to establish the antiquity of our duodecimal system, and have even claimed it as of divine origin. In their investigations they have made a most thorough exploration of the Great Pyramid, and here they have found an abundance of what they regard as conclusive evidence of the truth of their position.

What they regarded as one of their remarkable discoveries was that this Great Pyramid was situated at the center of all the dry land on the earth's surface. It is true that the parallel of latitude which passes through this Pyramid crosses more land than any other parallel, also that the meridian that passes through it likewise crosses more land than any other meridian, but it is not true that the hemisphere which has this Pyramid for its pole contains more land and less water than any other hemisphere. In fact there are several places which are the centers of more land than this Pyramid. The true center of all the dry land on the earth's surface is situated about 1,800 miles from this Pyramid and a little north of east.

The paper was highly interesting and at its close there was a discussion in which a number of members took part and a number of methods proposed for finding the center as above described

On motion adjourned. A. H. PORTER, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

358TH MEETING, JANUARY 20, 1892.—The club met at 8 p. m., at the club rooms, President Johnson in the chair and thirty-seven members and three visitors present. The minutes of the 357th meeting were read and approved. The Executive Committee reported the doings of the 123d meeting.

Mr. J. P. Seddon was elected a member of the club.

Mr. J. W. Woermann was proposed for membership.

Mr. Edward Flad then read the first paper of the evening on "An Inclined Cable Railway for Transferring Freight Cars between the Upper and Lower Yards of the Western Cable Railway Company."

The paper described the construction and operation of a cable road built for the purpose of transferring freight cars between the tracks of the Iron Mountain Railway and Lemp's Brewery in this city. The grade of Potomac Street, along which the road is built, is such that it is impracticable to operate with a locomotive, hence the cable system was adopted. Two loaded freight cars are transferred at each trip over a maximum grade of 7.2 feet per 100 feet.

This is the first road of the kind that has ever been constructed and hence it is of special interest. A number of novel features are introduced. There is a safety stop device, by means of which a train weighing 180,000 pounds moving down grade at the rate of five feet per second can be stopped within a distance of five feet without any serious shock, a hydraulic cushion being provided to take up the energy of the moving loads. Electric signals are transmitted between the train and hoisting engine through an electric wire placed in the core of the steel cable.

The paper was illustrated by blue prints giving full details of construction.

Discussion followed by Messrs. Farnham, Gayler and Seddon.

Mr. Whitfield Farnham then read the second paper of the evening.

Mr. Farnham gave a full account of the recent disastrous colliery explosion at McAlister, I. T. in mine 11 of the Osage Coal & Mining Company. The mine is well equipped, having duplicate pumps, steam and electric, duplicate fans situated at considerable distance from hoisting shaft; an electric plant for pumping and lighting, with the engines and boilers, is housed in substantial stone buildings. Two separate openings or escapements shafts besides the air shaft are provided, and are in daily use. The main shaft is 475 feet deep. The explosion was started at 5:04 p. m., by a blown out or "windy" shot or blast fired contrary to rules before the miners had been hoisted out of the mine. Gas or fire-damp was not a factor in the explosion, and powder played no part except as fired in the fatal shots in blasting down the coal. Coal dust seems the only remaining medium capable of carrying the explosion over the two thousand feet or more of entries which were affected by the accident. The work of rescue was prompt and effective, but thirty-seven men were brought up dead, and twenty more died in the twelve days following, while about 120 more were more or less injured, principally by burns.

Discussion followed by Messrs. Wheeler, Ferguson, Seddon, Potter, Hermann, Crosby, Johnson and Holman.

Adjourned. ARTHUR THACHER, Secretary.

359TH MEETING, February 3, 1892. The club met at 8 p. m., at the club rooms, President Johnson in the chair and thirty members and six visitors present. The minutes of the 358th meeting were read and approved. The Executive Committee reported the doings of its 124th meeting.

Mr. J. W. Woermann was elected a member of the club.

Mr. Robert Burgess was proposed for membership.

Mr. A. L. Johnson then read the paper of the evening on "Shop Work Inspection." The paper spoke of the difficult position of the inspector,

the duties he had to perform, and how best achieved. The processes of manufacture in mill and shop were taken up in detail and discussed. The writer opposed as unnecessary the requirement in the specifications for $\frac{3}{4}''$ round blow tests for steel. He also thought open hearth steel more reliable than Bessemer. He favored only one reaming in the shop, the holes being punched $\frac{1}{8}''$ smaller than the diameter of the rivet and then reamed after assembling. This would insure much better, more solid holes. The unreliability of machine countersunk rivets was also mentioned, and some reasons given therefor. The paper gave a method for keeping a very rigid account of the daily progress of all the parts of the structure under contract, from the mill to the finished member. This is especially advantageous in case any legal complications arise about the delay of the work. Tables were also given for the facilitation of the inspection and a more perfect record of the shop work.

Discussions followed by Messrs. Johnson, Gayler, Crosby, Hermann, Burnet, Ockerson, Pegram, Wheeler, Baier.

President Johnson introduced Mr. Robert Burgess, one of the engineers of the Intercontinental Railway Survey. Mr Burgess gave a short description of the work of the survey in the northern part of South America. The work, as far as it had progressed, showed that it would be perfectly feasible to construct an intercontinental railroad.

Adjourned. ARTHUR THACHER, Secretary.

360TH MEETING, February 17, 1892. The club met at 8 p. m., at Washington University, President Johnson in the chair and fifty members and eight visitors present. The minutes of the 359th meeting were read and approved. The Executive Committee reported the doings of its 125th meeting.

Mr. Robert Burgess was elected a member of the club.

Messrs. A. S. Cushman, A. H. Baldwin and Morris Wuerpel were proposed for membership.

The Secretary read a communication from the Committee of Engineering Societies of the Columbian Exposition in regard to the proposed Engineering Congress and the division of the different branches of engineering.

Mr. Robert Moore then spoke on the subject of "The Merchant's Elevated Terminal Railway." Mr. Moore exhibited a large number of views showing the work as it progressed from the foundations to the completion of the structure. A number of interesting tests in regard to fastening the anchor bolts for the columns were described, and it was shown that when the bolts were placed in rock, Portland cement was the most satisfactory. The illustrations showed in detail the manner of erecting the spans.

Prof. J. B. Johnson then described "A Straight Line Railway Survey Between St. Louis and Chicago." The survey now being made between St. Louis and Chicago for the Chicago & St. Louis Electrical Railway Company is proceeding in a direct line from a chosen point in East St. Louis to a chosen point in Chicago. A casual inspection of the region to be traversed indicated that a straight line road would probably fit the ground as well as any other, and would not pass through any town or village of importance, which for a high speed road is very desirable. The question of grade also is unimportant in this case, since grades as high 5 or 6 per cent. can readily be overcome by a single or double car electric service. Since the proposed speed is 100 miles per hour, it is a real advantage to avoid curves. If a straight line can as well be secured, therefore, as any

other, it was thought best to do so. The direction of this line has been computed from the known latitude and longitude of the two terminal points, and the line is being run by a transit, the forward points being set by double reversals of the instrument, and bisecting the space between the two positions. The Azimuth of the line will be checked every ten miles by observations on Polaris, made at any convenient hour, using a table especially computed for such work.

The subject was discussed by Messrs. Ockerson, Baier, Ferguson, Colby, Moore, Hermann, Crosby, Nipher, Blaisdel, Laird, Adams and Maxon.

Adjourned. ARTHUR THACHER, Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.
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MUNICIPAL GOVERNMENT WITH ESPECIAL REFERENCE TO THE MANAGEMENT OF PUBLIC WORKS.

A DISCUSSION BEFORE THE BOSTON SOCIETY OF CIVIL ENGINEERS, JANUARY 18, 1892.

INTRODUCTION BY PRESIDENT F. P. STEARNS.

We have before us for discussion this evening the subject of Municipal Government, and although we have never before discussed it as a Society, I believe you will agree with me that it is an appropriate subject for our consideration.

Among the most important functions of municipal government are the ordering, construction and maintenance of the great public works of a city, such as the streets, water works, sewers, and parks.

To ascertain the ratio of expenditures for these and other public works to the expenditures for other purposes I have classified the expenditures of the City of Boston for the financial year 1890–91 under a few prominent heads, omitting, however, all interest, debt and sinking fund payments, and other items of a purely financial nature. The results obtained are as follows:

Construction and maintenance of public works	$ 7,500,000
Public safety and charity	4,100,000
Educational (exclusive of buildings)	1,800,000
Financial, legal and miscellaneous	1,000,000
	$ 14,400,000

It will be seen from this statement that fully one half of the city's expenditures are for public works, which are for the most part directly within the province of the civil engineer.

Even the proportion of the total expenditure here mentioned does not at all fully represent the importance of the public works as a factor in the problem of municipal government: for I believe that if any city had a system by which the public works could be wisely, prudently and honestly ordered, constructed and maintained, it would very nearly have solved for itself the vexed problem of municipal government.

It is self-evident that no system will insure complete success in the management of public works so long as it is possible to place incompetent and dishonest men in charge; but it is also true that the character of the men selected and the efficiency of their work depends very much upon the system employed; and the adoption of a good system is therefore a long step towards good government.

Having reached the conclusion that Municipal Government should be the subject for one of our meetings this winter, we endeavored to learn which of the existing governments of the larger cities would furnish the most instructive example for presentation in the main paper of the evening, and our choice fell upon St. Louis. It was then our rare good fortune to obtain from Mr. Robert Moore of that city not only the promise to furnish the desired paper, but also to be with us this evening. This promise is now fulfilled and it gives me great pleasure to present to you Mr. Robert Moore, now Chief Engineer of the St. Louis Merchants' Bridge Terminal Railway, and formerly a member of the Board of Public Improvements of that city.

MUNICIPAL ENGINEERING IN ST. LOUIS.

BY ROBERT MOORE, C. E.

Nothing more distinguishes the city of to-day from the city of former times than its great and ever growing dependence upon engineering works. The cobble stone pavement of the ancient town is replaced by granite and concrete, and the iron tramway. Underneath the surface is now found an intricate network of water pipes, gas pipes, electric conduits and sewers, upon whose right working depends the city's life and health; whilst its commerce is dependent upon harbors and bridges, telegraphs and railways which it has been the work of a generation of engineers to construct. Modern city government is in large measure a matter of municipal engineering, and that city is governed best in which this work is carried on with the greatest skill and success.

As a contribution to the study of this most important branch of city government, a statement of the somewhat exceptional experience

of the chief city of the Mississippi Valley in this line of work is worthy of record.

In the year 1875 the State of Missouri adopted a new constitution, in which was engrafted a provision authorizing the City of St. Louis to enlarge it boundaries, abolish the dual and often conflicting government of city and county, and conduct its local affairs in accordance with a charter to be framed by its own citizens.

In pursuance of this provision there assembled, in the spring of the following year, a board of thirteen freeholders chosen by the people, charged with the duty of framing a new city charter. The board contained a number of able and public spirited men, skilled in city affairs, and, as a whole, was exceptionally well fitted for its work. At the end of the ninety days, to which by law their deliberations were limited, they submitted for approval by popular vote, a charter which was, in many of its features, a new departure, particularly in the machinery provided for the conduct of the city public works.

The charter thus framed was ratified by the people; and on October 22, 1876, became the organic law of the city.

In order to make clear the changes in the machinery and methods of municipal engineering effected by this new law, it is necessary to explain how this work was done prior to this time.

The charter of 1870 and the ordinances in force in 1876, created a department of the city government, styled "The Engineer Department," in charge of an officer called the City Engineer. This officer was appointed by the Mayor, subject to approval of the City Council, for a term of two years, the same time as that of the Mayor, and at the same salary, $4,000 per year. Like other appointed officers he was subject to removal or suspension by the Mayor, with no restriction except that he must report the facts of the case to the City Council at its next meeting. The City Engineer was, by the charter, required to be "a thorough practical and experienced civil engineer," and, with the aid of such assistants, clerks and agents as should be required, was to have charge of "all city improvements, works, repairs and buildings, and the performance of all contracts for the same." He was also required to let all contracts for public work, such lettings to be duly advertised and the work awarded "to the lowest and best bidder." The Council was expressly forbidden to let any public work, or to fix the price or rate therefor.

The engineer was also authorized, with the approbation of the Mayor, to employ his own subordinates, and, subject to the same approval, to dismiss them whenever, in his opinion, the interests of the city would be subserved thereby, and to employ other persons in their stead.

The ample jurisdiction thus granted to the City Engineer over "All

city improvements, works, repairs and buildings, and the performance of all contracts for the same" was, however, subject to several important qualifications.

First of all, he had nothing whatever to do with the city water works, the entire control of which in all its departments was, by special statute (March 13, 1867,) vested in a Board of Water Commissioners, composed of three men appointed originally by the Legislature, and subsequently by the Mayor. This Board employed its own chief and assistant engineers, who were wholly independent of the city engineer.

In the second place, in the department of sewers he had only a limited and subordinate jurisdiction. By an ordinance dating back to 1859 (Ord. 4535, Nov. 25, 1859.) this department was placed in charge of a committee of the City Council styled "The Sewer Committee," of which the City Engineer was the chief executive officer, but not a member. This Committee fixed the boundaries of sewer districts, decided upon plans, directed the letting of work, granted permits for sewer connections, passed upon the employment and discharge of all men employed in the department, and certified all bills involving the expenditure of money. The City Engineer attended all meetings and kept the journal of the committee. He made estimates of work done, and upon the completion of district sewers, certified the special tax bills upon the property drained. He made plans for the committee; but, in the final decision upon them was without a vote. In all work of this class he had no power except to carry out the instructions of the Sewer Committee.

In the protection and improvement of the harbor, and in the construction, repair and cleaning of streets, his powers were more ample, and these were, in consequence, the chief fields of his activity.

The changes in the organization of the city government made by the charter of 1876 were numerous, and some of them quite radical. The number of wards was increased from twelve to twenty-eight, and the city legislature, or "Municipal Assembly" enlarged from one to two houses, called respectively the Council and House of Delegates. The Council was composed of thirteen members, elected for four years on general ticket; the House of Delegates, of twenty-eight members, one from each ward, elected for two years. The powers and duties of the Mayor were left substantially unchanged, but his term of office, with that of all other elective or appointive offices, was increased to four years. The term of all elective officers was made coincident with that of the Mayor, but the term of all appointive officers was made to extend from the middle of one Mayor's term to the middle of his successor's term; so that normally, no appointments were to be made by any Mayor until the beginning of his third year in office.

Most sweeping of all, however, were the changes in the organization of the municipal public works. By the new charter the offices of the City Engineer, the Sewer Committee and the Board of Water Commissioners, are abolished, and in their stead is established a wholly new body, styled "The Board of Public Improvements, to the members of which, acting in part jointly, and in part singly, is committed the management and execution of all the city works.

This body is composed of a president, elected by the people, and five commissioners, appointed by the mayor with the approval of the Council. These commissioners are styled, respectively, the Street Commissioner, the Water Commissioner, the Sewer Commissioner, the Harbor Commissioner and the Park Commissioner. In case the city should acquire the city gas works, a further member of the board, entitled the Gas Commissioner, is provided for.

As individuals, each of these five commissioners is, by the charter and ordinances in pursuance thereof, made the executive head of the department indicated by his official title; and as such is charged with the execution of all contracts, and the enforcement of all ordinances relating to his department, and is responsible for all the acts of his subordinates. As part of this responsibility, all of his subordinates are appointed by the commissioner, part of them subject to the approval of the Mayor, and part subject to the approval of the President of the Board of Public Improvements, and all of them are removable by him at his pleasure. Each commissioner may himself be removed by the Mayor or by the Council for cause; but if removed by the Mayor, the Council appoints his successor: if removed by the Council his successor is appointed by the Mayor without concurrence of the Council.

The President of the Board in his individual capacity is head of the Special Tax Department, and as such must make out and sign all bills of special assessment for street and sewer construction, and for street sprinkling. The department of public buildings, though in immediate charge of a Commissioner of Public Buildings, is also under the supervision and control of the President of the Board. He is also charged with a general supervision over the departments of the other members of the Board, and it is made his duty to inform the Mayor and Municipal Assembly of any dereliction of duty of any commissioner.

To the Board of Public Improvements, acting as an organized body, is committed:

First. The letting of all contracts for public work, and preparation of specifications and forms of contract therefor. A carefully drawn ordinance, prepared by the Board, prescribes the rules to be observed in all lettings. The award, if any, must always be made to the lowest bidder, and the contract, when executed, is subject to approval of the Council.

Second. The preparation and recommendation to the Assembly, of ordinances for the following classes of public work:

1. For the opening, widening, construction, reconstruction, repairs, and sprinkling of streets, and the making of all excavations therein.

2. For the establishment of sewer districts, and for the construction, repair and cleaning of all public and district sewers, and the making of all sewer connections.

3. For the laying of water pipes, and the making of all attachments thereto, as well as the extension, construction and repairs of the water works.

4. For the improvement, protection, repairing and cleaning of the levees, wharf and harbor.

5. For the improvement and maintenance of the public parks, and

6. For the erection, extension and repairs of public buildings.

In this matter of the preparation of ordinances for public work, the Board is in effect a third branch of the city legislature. With regard to street and sewer work, the charter in fact provides that no ordinances shall be valid unless first approved by the Board of Public Improvements.

As a preliminary to the preparation of ordinances for street construction or reconstruction, the Board is required to give two weeks public notice of its intention to consider the matter, at which meeting all parties interested may appear and be heard in regard to it. If the owners of a major part of the property on the line of the proposed improvement shall remonstrate against the same, no ordinance therefor can be forwarded by the Board except by the concurring vote of all its members; otherwise a majority vote only is required.

Third. A further duty of the Board is the direction and management of the lighting of streets, alleys and public buildings, which is now done wholly by electricity. The superintendent of the city lighting is an appointee of the Board, and subject to its orders.

Fourth. To the Board is also committed the management and control of the city work-house, the superintendent of which, though appointed by the Mayor, is subject to the orders and instructions of the Board.

The Board is required to meet at least once in each week, and to keep a record of all its proceedings, acts and orders, an abstract of which must be published in the newspapers doing the city printing.

Owing to delays of various kinds, the machinery thus outlined did not get into working order until the summer of 1877, when the organization of the new board was completed under the presidency of Col. Henry Flad, Past President Am. Soc. Civil Engineers. With the single exception of the Water Commissioner, the late Thos. J. Whitman, who had been the Chief Engineer of the Board of Water Commissioners,

the new commissioners, of whom the writer was one, were without previous experience in the special departments over which they were called to preside. But all were animated by a common desire to so organize and conduct the work committed to their charge as to secure the best possible results, and establish the new regime in the confidence of the people.

That they were successful is, so far as the writer is aware, the unanimous verdict. The public works of the city have been managed with economy and skill, and without the slighest suspicion of jobbery. City work is, in fact, as well and as honestly done as that of any private individual or corporation; so that, in cases where an option is given to the property owner to do work, such as sidewalk or alley paving, himself, or to have it done by the city at his expense, it is found to be uniformly cheaper and better to have it done by the city.*

The full control and responsibility given by the new system to each commissioner over his own department, has naturally placed integrity and fitness at a premium in the appointment of subordinates to the disregard of political and other irrelevant considerations. Each has been free to organize and manage his force with an eye single to obtaining the best work, both in quantity and quality, and where this is done success is easy and certain.

Another thing which has contributed much to the efficiency of the various departments has been the opportunity of the commissioners to refer doubtful points of policy to the full Board for advice and counsel. Backed by the prior endorsement of the Board they are thus enabled to take with safety responsibilities which they could not otherwise do without great danger of misconstruction, and consequent loss of public confidence. For a public officer must not only do right, but must also be thought to do so by the community whom he serves. In matters of doubt the confidence of the public is more easily retained by a Board than by any single man; just as a full bench of judges is stronger as against calumny than any single judge, however pure his motives, can ever be. There has thus resulted for the various commissioners a great gain in the confidence of the public, with a corresponding gain in the efficiency of the several departments.

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*An example of this came within the writer's own experience a few months ago, when, in the construction of an elevated railroad, it became necessary to move quite a length of water and gas pipes. In the one case the city water department, and in the other the gas company, was called upon to do the work at the expense of the railroad company. The result was, that the work of the gas company was done at an excessive cost, due to discipline and methods so lax that the railroad company was charged with time during which the workmen were employed digging up old lead water pipes and carrying them to a junk shop for sale. The city work, on the other hand, was done promptly and well, and at a cost much less than if it had been done by the railroad company itself.

As regards the matters committed to the Board as a whole, it may be noted, first of all, that under the new system, the letting of contracts for public work is conducted in a manner that leaves nothing to be desired. Every precaution is taken to put all bidders upon an equal footing. The character and quantities of the work are ascertained with the utmost care, and given in advance to all persons interested. All bids must be made upon blanks furnished by the Board, and no bid is accepted unless accompanied by a certificate of the City Treasurer that earnest money, amounting in some cases to ten per cent. of the estimated value of the work, has been deposited with him. At the hour appointed the bids are all opened and read in a public meeting of the Board. After a due time in which to canvas the several bids, the award, if any, is made to the lowest bidder, not the lowest and best bidder as under the former charter; but the Board may, if it sees fit, reject all bids and order a new letting.

As heretofore carried out, this system of letting public work has given universal satisfaction, without even the slightest suspicion of favoritism or jobbery. That is to say, one of the most fruitful sources of municipal misrule has been completely removed.

In its legislative functions, the success of the Board of Public Improvements has been equally pronounced. The ordinances for public work recommended by them have been prepared with great care, so that when sent to the Municipal Assembly, they have embodied the results of the best skill and judgment of every member of the Board. Where ordinances originating with the Board have been rejected by the Assembly, it has never been because of any defect of form or method, but because of their unwillingness to do by any method the thing proposed. There can be no doubt that the provision requiring the Assembly to pass or reject without amending bills originating with the Board has insured the city against technical blunders which would otherwise certainly have been made, and is eminently wise.

The wisdom of the framers of the St. Louis charter of 1876 has therefore, been fully vindicated by the test of time, and the general plan of conducting municipal engineering work proposed by them is one which can be recommended without reserve to any large city.

The central ideas of this plan are:

1. The subdivision of the engineering work of the municipality into several departments under the executive control of one man, who should be a man of strong character and mature judgment, and an expert in the special work under his charge.

2. The creation of a Municipal Engineering Council or Board of Experts, composed of the heads of the several engineering departments, co-ordinated under the presidency of an engineer of high rank, to which Board all questions concerning the administration of the city works

may be referred, and to whose special charge should be committed the letting of all contracts for public work, and the initiating of all legislation concerning the same.

The particular method adopted in carrying out this general plan should be suited to the local requirements of each city. The one adopted in St. Louis does not seem to be quite the best, even for that city. It would be better, in the writer's judgment, to leave out from the Board the Park Commissioner and Harbor Commissioner, a very small part only of whose work is of an engineering character, and in their places put the Commissioner of Public Buildings, or City Architect, and the Commissioner of City Lighting, under whose charge should be placed the supervision in the public interest of all electric installations.

Of course it goes without saying that neither this system nor any other will give satisfactory results if committed to the hands of incompetent or corrupt men; although it will do much, even then, to limit the harm done which can be done by any one man. But, if carried out in good faith, by the selection of capable and honest men as members of the Board, this method of conducting municipal engineering work has several important advantages over the older method which in St. Louis it has superseded.

1. It avoids the absurdity of expecting any one man to be master of all the branches of engineering involved in the public works of the modern city, by sub-dividing the work to such an extent as to make it possible for the several commissioners to give the problems of their own special work the concentrated attention and study necessary for their complete solution.

2. By centering in one man the executive control of each department, the highest degree of responsibility and efficiency is promoted.

3. By delegating to the Board composed of the heads of several departments of public work, the preparation of all ordinances for such work, the city secures the great advantage of the matured judgment of a permanent and responsible body of experts.

4. The opportunity to present all matters of an unusual or doubtful nature to the full Board for record and for advice, is a most valuable resource and protection to the individual commissioner.

5. The placing of all lettings of public work in the hands of the Board not only relieves the individual commissioners of work in which the liability to charges of favoritism and malfeasance are the greatest but insures the utmost publicity and fairness in the awarding of contracts, thus securing to the city the full benefits of open and honorable competition and the services of the best class of contractors.

In a word the system is one under which both the officer and the city are protected to the equal advantage of both, and is the best for a large city that has yet been proposed.

Communication in Relation to the St. Louis Charter.

BY COL. HENRY FLAD, LATE PRESIDENT OF THE BOARD OF PUBLIC IMPROVEMENTS OF ST LOUIS.*

The system of carrying on public works which has been in operation in St Louis since 1876, has given general satisfaction. The provisions of the Charter have been fully stated and explained by Mr. Robert Moore in the valuable paper lately read before your Society. Those provisions which I consider of the greatest importance and value are:

1st. The appointment, by the Mayor, of Commissioners, each as the head of a department in charge of one or more branches of Public Work and each Commissioner to be responsible for the arrangement of his department.

2nd. The creation of a board composed of these Commissioners with a president elected by the people.

3rd. The provision that all ordinances for Public Work must be prepared and recommended by such board, vesting in the Municipal Assembly the power to adopt or reject ordinances recommended by the board, but not to amend such ordinances and prohibiting it from directly entering into contract for any Public Work.

4th. The provision giving to each commissioner the right to appoint and discharge all subordinates in his department.

The changes which I would suggest in the St. Louis Charter are:

1st. That the law should provide that the president must be a Civil Engineer and that every Commissioner must be an expert in the special branch of Public Work allotted to his department and that the selection of Commissioners should not be limited by any condition in regard to length of residence in the city.

2nd. That the appointment of subordinates should not be made subject to the approval of the Mayor.

3rd. That clerks and inspectors appointed by Commissioners should be selected from among persons who have successfully passed an examination, under such rules and regulations as may be adopted by the board.

4th. That the law should prohibit the Municipal Assembly from granting relief to contractors or from releasing them from any fines or penalties incurred under contracts, except on the unanimous recommendation of the board.

5th. That the water works and sewers be placed in charge of the same Commissioner; that parks and harbor be placed in charge of the Street Commissioner; that the construction and repair of all public

* The general discussion of Mr. Moore's paper which took place at the time it was read, will be found on page 156, *et seq.*

buildings be entrusted to a Commissioner, which position should be filled by an architect and that a department of lighting and heating should be created and placed in charge of an electrical engineer.

Local conditions in other cities might of course require a different arrangement of departments.

GOVERNMENT OF BOSTON.*

BY WILLIAM JACKSON, CITY ENGINEER.

ORGANIZATION.

Mayor:—The Mayor is the chief executive officer of the city and exercises through the several officers and Boards of the city, the executive powers of the city and all the executive powers now or hereafter vested in the Board of Aldermen as Surveyors of Highways, County Commissioners or otherwise. The charter provides that neither the City Council, nor either branch thereof or any committee thereof shall directly or indirectly take part in the employment of labor, the making of contracts or in the care of public property.

City Council:—A Board of twelve Aldermen and of seventy-five Common Councilmen constitute a City Council, they are elected yearly and sit and act as separate bodies except when they meet in convention. The Board of Aldermen are also County Commissioners of Suffolk County and Surveyors of Highways. The City Council makes appropriations, levies taxes, authorizes loans and may make such by-laws and ordinances as towns have power to make: and may by ordinance provide for the appointment and salary of the necessary officers excepting those prescribed by statute.

School Committee:—A School Committee is elected by the people: it

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*The short papers which follow, giving brief outlines of the municipal government of the cities of Boston, New York, Providence, Buffalo, Philadelphia, and Paris, France, were prepared at the request of the President of the Society. It was suggested that for the purpose of comparison, the following points should be brought out:—

1. A very brief outline of the organization of the city government as a whole.
2. A somewhat more complete statement of the organization so far as it relates to public work.
3. The method of appointment and removal.
4. If appointees are required by law to have any professional qualifications please state them.
5. Tenure of office.
6. The method of ordering public work done and of raising money for the same.

consists of twenty-four persons, eight chosen each year, they have entire charge of the schools.

Finances:—The finances of the city are cared for by a City Treasurer, a City Collector, an Auditor and a Board of Sinking Fund Commissioners, consisting of six members. Taxes are assessed by a Board of nine principal Assessors, assisted by thirty-seven first assistants and thirty-seven second assistants.

Institutions:—A Board of Overseers of the Poor, consisting of twelve persons has charge of what is known as the "out door relief" of the poor and also of bequests and of property held for the benefit of the poor of the city and of the expenditure of the income from the same. A Board of Commissioners of Public Institutions consisting of three persons, has charge of the House of Correction, the House of Industry, the House of Reformation, the City Lunatic Hospitals, the City Homes for poor and City Homes for neglected children.

Health:—A Board of Health, consisting of three persons, exercise all the power of the City Council and of the Board of Aldermen relative to the public health, they also have charge of the City Cemeteries, except Mount Hope Cemetery, which is in the charge of a Board of Trustees. There is, independent of the Board of Health, an Inspector of milk, and vinegar; and an Inspector of provisions. The City Hospital is in charge of a Board of five Trustees. A City Registrar keeps the records of births, deaths and marriages and issues certificates of all intentions of marriage.

Police:—The Police Department is in charge of a Board of three Commissioners appointed by the Governor of the State.

Fire:—A Board of three Fire Commissioners has charge of the Fire Department, the fire alarm and the supervision of all wires over streets or buildings and of every wire within a building designed to carry the electric light or power current. They also have the supervision over business which is liable to cause fire. A Fire Marshall is appointed by the Governor.

Buildings:—An Inspector of Buildings has supervision over the construction of all buildings, to see that they are built in accordance with the law. he also keeps a register of plumbers and issues permits for doing plumbing. The City Architect, unless otherwise specially ordered, makes all contracts for, and has the charge of the construction of, all public buildings built by the city. The Superintendent of Public Buildings except as otherwise provided, has charge of all repairs and of the care and maintenance of the public buildings and of buildings hired by the city, he also provides all furniture for the different departments and has charge of all city property in the armories provided by the city for the militia.

Streets:—The Superintendent of Streets has charge of the construc-

tion and maintenance of streets and sewers, of the maintenance of bridges, of the cleaning of the streets and of the removal of ashes, garbage, etc. He makes all contracts and employs all necessary labor. He appoints all draw tenders for the draws in bridges under his care. He keeps a plan and record of the construction of each sewer and of all sewer assessments levied. No person or other city department can open the streets for any purpose without a permit from the Superintendent of Streets, and when about to make a new street or to new surface any street, due notice is given by him to the city departments and to all persons authorized to place any structure in such street, and after the street is completed no permit can be granted for the term of one year except in case of obvious necessity. Sewers can only be connected with, by permit from the Superintendent and after payment of sewer assessments. All permits for opening the streets issued by the Superintendent are conditioned for proper lighting, protecting and for putting the streets in satisfactory condition and for maintaining the surface for six months. The Superintendent of Streets also issues permits when authorized by the Board of Aldermen for using portions of the street for coal-holes, vaults, etc., also for occupying portions of the street, not exceeding fifteen minutes, for raising and lowering merchandise, also for moving buildings, also for laying, maintaining and using wires, railway tracks, pipes, conduits and poles. Except from City Departments, a bond is required before any permit may be delivered and no permit shall be given to any person within a year after violating the conditions of his permit. The principal officers of the Superintendent are, a Secretary and Executive Engineer, a Purchasing Agent, a Deputy Supt. of Paving Div., a Deputy Supt. of Sewer Div., a Deputy Supt. of Bridges Div., a Deputy Supt. of Sanitary Div., and a Deputy Supt. of Street Cleaning Div.

A Board of Survey, consisting of three persons to serve three years was appointed in 1891, to make plans showing the locations and grades of such highways as in their opinion are necessary for the present or future interests of the city. A Board of Street Commissioners, consisting of three persons has power to lay out, widen and discontinue highways, (subject to the approval of the City Council when the cost exceeds $10,000;) and to order specific repairs. No way can be opened to public travel until approved by the Commissioners; they may also when the conditions required by law are complied with, order the construction of any way shown on the Board of Survey plans. The Board is also a Board of Appeal in cases of over assessment of taxes.

Ferries:—A Superintendent of Ferries has charge of the maintenance and running of the East Boston Ferries.

Lamps:—A Superintendent of Lamps has charge of lighting the streets and of making contracts for same.

Cambridge Bridges:—A commission composed of two persons, one each appointed by the cities of Boston and Cambridge, has charge of Harvard, West Boston, Craigie and Prison Point Bridges.

Water Works:—A Water Board consisting of three persons has the care, control and maintenance of all waters, reservoirs, aqueducts, pumping stations and other property held by the city for supplying water to its inhabitants, also the charge of the construction, purchasing and maintenance of all pipes, conduits and other appliances for obtaining and supplying water: and furnish and repair meters and keep a record of each meter, and also from time to time determine the tariffs for the use of water. The works are divided into three divisions viz: The Eastern and the Western Divisions of the Sudbury and Cochituate Water Works, and the Mystic Division, each division being in charge of a Superintendent. A Purchasing Agent purchases the supplies required for the different divisions. A Water Registrar assesses the rates and makes contracts for furnishing water according to the tariffs established by the Water Board, he receives and transmits to the Water Board applications for pipes for supplying water to the premises of takers, and at least once a year, causes the premises of all water takers to be examined, he also has charge of the shutting off and turning on of water from the premises of takers. The water works are self-sustaining.

Parks:—A Park Commission consisting of three persons has the charge of the construction, improvement, government and regulation of the various parks included in the system of Public Parks. They make by-laws and ordinances for the government of the parks, fix penalties not to exceed twenty dollars, and appoint Park Police.

Public Grounds:—A Superintendent of Public Grounds, has charge of the Common, the Public Garden and of the Public Squares.

Engineering:—A City Engineer has charge of all engineering work for the different departments, (excepting the sewer division of the Street Department,) and of the construction of all Public Works of the City which properly comes under the direction of a civil engineer, unless otherwise specially provided.

Surveying:—A City Surveyor has charge of the making of such surveys and levels as may be required by the different departments excepting the sewer division of the Street Department, and the custody of all surveys and plans relating to the laying out, widening, extending and grading of streets.

Printing:—A Superintendent of Printings has charge of all the city printing and furnishes stationery to the departments.

Law:—The law department is under the joint charge of a Corporation Counsel and a City Solicitor.

Records:—A Record Commission composed of two persons has

charge of the collection and preservation of the records and documents relating to the city.

Other officers are: a Board of Registrars of Voters, consisting of three members; an Art Commission; a Director of Workingmen's Loan Association; a Director of Collateral Loan Co.; two Managers Old South Association; Superintendent of Market; Election Officers; Constables; Sealer of weights and measures; Weighers of coal, of beef, of boilers, etc., and of fish; Inspectors of lime, of petroleum, and of hay and straw; Measurers of upper leather, of grain, of wood and bark, and of vessels and ballast; Culler of hoops and staves; Surveyor of marble; Superintendent of hay scales; Fence Viewers; and Field Drivers.

APPOINTMENT AND REMOVAL.

The Street Commissioners are elected by the people, the City Clerk, City Messenger and Clerk of Committees are elected by the City Council, the Clerk of the Common Council is elected by the Common Council; all other heads of departments and other public officers, except the Police Commissioners, are appointed by the Mayor subject to confirmation by the Board of Aldermen. The Police Commissioners are appointed by the Governor of the State, subject to confirmation by the Governor's Council. All subordinates are appointed by the heads of the different departments, subject to the approval of the Mayor. The Mayor may remove any of his appointees for such cause as he may assign to his order of removal, and heads of departments may remove their appointees in like manner.

QUALIFICATIONS.

Appointees are not required by law to have any professional qualification.

TENURE OF OFFICE.

Excepting officers whose term is fixed by statute, the term of office of every person who is a trustee or member of a board, except the Record Commissioners and Trustees of Mount Hope Cemetery, is three years from the first day of May in the year of appointment and until a successor is elected or confirmed, and the term of the Record Commissioners, of Trustees of Mount Hope Cemetery and of all persons having sole charge of a department is for one year from the first day of May in the year of appointment, and until a successor is elected or confirmed. All officers and boards in charge of departments of the city, appoint their respective subordinates. All subordinates receiving a yearly salary, continue in office, until removed by the officer or board under whom they serve for such causes as said officers or board shall deem sufficient and shall assign in the order for removal; all other employes may be discharged at pleasure. Appointments are subject to the Civil Service Rules.

HOW PUBLIC WORKS ARE ORDERED AND MONEY RAISED.

Public Works are authorized by the City Council except in special cases, when the Legislature exercises its power. In theory the ordinary running expenses and the minor public works of the city are paid from the tax levy, and permanent improvements of magnitude are paid for by loans; the city being authorized to incur a net debt, exclusive of water debt, of not more than two per cent. of its average assessors' valuation for the previous five years, and the Legislature in its discretion authorizes loans outside of the debt limit. The tax rate is limited to not exceed $9 per $1,000, of the average assessors' valuation for the previous five years, exclusive of the state and county taxes and of sums required on account of the city debt.

GOVERNMENT OF THE CITY OF NEW YORK.

BY HON. FRANCIS M. SCOTT, AQUEDUCT COMMISSIONER.

The government of the City of New York, like that of most municipalities may be roughly divided into three general divisions: the Executive, the Financial and the Legislative.

The Executive functions are vested in the Mayor and several Departments, which, for the most part, are directed by Boards of Commissioners.

The Mayor is elected at a general election, holds office for two years, and is removable by the Governor, upon charges and after a hearing. The President of the Board of Aldermen, also elected at a general election, and holding office for two years, is in effect the Vice-Mayor, exercising the Mayoral powers in case of a vacancy in the office of Mayor, or in the absence or disability of that official.

The Executive Departments, properly so called are the Law Department, the Police Department, the Department of Public Works, the Department of Public Charities and Correction, the Fire Department, the Health Department, the Department of Public Parks, the Department of Taxes and Assessments, the Department of Docks, the Department of Street Cleaning and the Board of Excise.

Of these Departments, whose respective functions are indicated generally by their titles, the Law Department, the Department of Public Works and the Department of Street Cleaning are single headed; the others being directed by Boards composed of either three or four Commissioners.

The heads of these Departments are appointed by the Mayor, hold office for fixed terms of three, four or six years, and (except the Commissioner of Street Cleaning and the Commissioners of Excise,) are

removable by the Mayor, with the consent and approval of the Governor of the State, for cause, and after having been afforded an opportunity to be heard.

The Commissioner of Street Cleaning is removable by the Mayor with the approval of the Board of Health, and the Commissioners of Excise are removable by the Governor.

In no instance, save in the case of the Commissioner of Street Cleaning, is the consent, approval or confirmation of any person or body, necessary to an appointment by the Mayor. In the excepted instance the consent of at least two members of the Board of Health is required. An official known as the Commissioner of Street Improvements of the 23d and 24th Wards, exercises as to the streets and other thoroughfares in that part of the City lying north of the Harlem River, all the powers exercised by the Commissioner of Public Works in other parts of the City, and possesses as to those Wards many of the powers vested in the Board of Aldermen as to the remainder of the City. He is elected by the electors of the Wards in which he exercises jurisdiction, holds office for six years, and is removable by the Mayor subject to the limitations applicable to the removal of the heads of other Departments.

The chief financial officer of the City is the Comptroller who is the head of the Department of Finance, and either directly or through bureaus in his department, receives and disburses all taxes and revenues, audits and pays all claims against the City, has power to compromise or adjust all claims in favor of or against the City, prescribes the forms of keeping and rendering all City accounts, and has the right to inspect and revise the accounts of all the City Departments, and generally controls and directs the financial concerns of the City. He is elected at a general election, holds office for three years and is removable by the Governor for cause.

The powers of legislation reserved to the City are very small, its affairs and the powers and duties of its officers being very minutely prescribed by the Statutes of the State. It has a Board of Aldermen, possessing very limited legislative functions, but which still retains some power to adopt ordinances which, to become effectual, must be approved by the Mayor, or passed a second time over his veto. This Board, in addition to the President above referred to, consists of twenty-five Aldermen elected by Districts, holding office for one year, and subject to expulsion and consequent deprivation of office by the Board.

The Board of Health has very extensive powers of enacting ordinances for the preservation and security of life and health. These ordinances have all the force and validity of penal statutes; any violation of them is a misdemeanor, and is punishable by fine or imprisonment or both.

The Dock Department is also invested with power to make similar ordinances relating to the matters under its charge.

The Department of Public Works is presided over by a single Commissioner, who is empowered to appoint a Deputy.

This Department has cognizance and control:

1st: Of all structures and property connected with the supply and distribution of Croton Water.

2nd: Of the collection of the revenues arising from the sale or use of Croton Water.

3rd: Of opening, altering, regulating, grading, flagging, curbing, guttering and lighting streets, roads, places and avenues.

4th: Of the repairing and construction of public roads.

5th: Of the care of public buildings.

6th: Of the filling of sunken lots.

7th. Of public sewers and drainage.

8th: Of street vaults and openings in sidewalks.

9th: Of paving, repairing and repaving streets and keeping the same clear of obstructions and of the re-laying of pavements removed for any cause.

10th: Of digging and constructing wells.

11th: Of the care, management and maintenance of the Public Baths.

12th: Of the location, erection, establishment and maintenance of public urinals.

The work of this Department is divided between a number of bureaus.

The only bureau as to the chief officer of which the law prescribes any professional qualifications is that having immediate charge of the structures and property connected with the supply and distribution of Croton Water; this officer is designated the "Chief Engineer of the Croton Aqueduct". and it is provided by statute that he and his Assistant Engineer "must be Civil Engineers of at least ten years' experience".

The sewer system of the City is also in charge of an officer known as the "Engineer in charge of Sewers," and he is always an Engineer by profession, although his office is not specially designated by statute, having been created by the Commissioner of Public Works under a general law authorizing him to employ Engineers, Surveyors and other persons to devise, frame and construct a general sewerage system for the City.

Except as above stated, no professional qualifications whatever are prescribed by law for the Commissioner of Public Works, his Deputy, or any of the heads of bureaus in his Department.

The Deputy Commissioner, Chief Clerk, Consulting Engineers and

the Heads of Bureaus are appointed by the Commissioner at pleasure without any examination save such as he may choose to make. All other positions in the Department, save those of Axemen, Laborers, and the like, are appointed by the Commissioner after competitive examination by the Examiners of the Civil Service Board. All the regular clerks and heads of bureaus are protected from arbitrary removal by the general provision of the City Charter that "they may not be removed until they have been informed of the cause of the proposed removal, and have been allowed an opportunity of making an explanation." All employees other than regular clerks and heads of bureaus are subject to removal at the pleasure of the Commissioner, unless they were "Veterans of the late War," in which case by operation of a general State Law, they can be removed only upon charges, for cause, and after trial.

The Dock Department, presided over by a Board of three Commissioners, and the Park Department under the charge of four Commissioners, have the custody, management and control of the classes of public works indicated by their respective titles.

Reference has already been made to the public works under the direction of the Commissioner of Street Improvements for the 23d and 24th Wards.

There is no statute prescribing any professional qualification for any of the above named Commissioners, nor for any of their employees, although in all of these Departments, Engineers are of necessity employed.

A special Commission, composed of the Mayor, Comptroller, Comsioner of Public Works and four Commissioners appointed by the Mayor, are at present engaged and have been since 1882, in building a new Aqueduct and a series of new Reservoirs for the purpose of increasing the Water Supply of the City; the structures erected by them, passing upon completion, under the care and management of the Department of Public Works.

Speaking generally, it may be said that all public work in the City of New York is performed by contract, awarded to the lowest bidder upon sealed bids and proposals.

The terms of the contracts and specifications are prepared by the head of the Department ordering the work, and are examined and approved as to form by the Counsel to the Corporation. Bids are invited by advertisement in the City Record, a paper published by the City.

The head of Department may, and as a rule, does require a certified check in an amount specified by him, to be deposited with the bid. The checks of the unsuccessful bidders are returned to them as soon as the bid is awarded, and the check of the successful bidder is returned to him when he and his sureties execute the contract; if a bidder to whom

a contract is awarded refuses to execute the contract, his check is forfeited. On the day and hour specified the bids are publicly opened by the head of Department, in the presence of the Comptroller or his representative.

The head of Department may reject all bids and re-advertise, but if he awards the contract it must be to the lowest bidder; though no bid can be accepted from or contract awarded to any person who is in arrears to the City upon debt or contract, or who is a defaulter, as surety or otherwise, upon any obligation to the City.

The cost of regulating, grading, paving, curbing and guttering of streets, laying of cross-walks, construction of sewers, fencing of vacant lots, and a few other local improvements is assessed upon the property benefited.

A Board of four Assessors is appointed by the Tax Commissioners. To this Board, the head of the Department under whose directions the work was done, certifies the total cost of the work. The Comptroller certifies the amount of interest chargeable upon each payment on account of the work from the date of payment to a date sixty days after the date of his certificate.

The Board of Assessors then assesses rateably upon the property benefited by the work the aggregate amount of the cost and interest. An aggrieved property owner can appeal to a Board of Revision, composed of the Comptroller, the Counsel to the Corporation and the Recorder. Their determination is final. The amount assessed becomes a lien upon the property which can be sold to satisfy it.

The money necessary to pay for the work as it progresses is raised by the Comptroller by the sale of Assessments Bonds which are redeemed out of the proceeds of the assessment when collected. Such public works as are not paid for by assessment are provided for either out of taxation, or out of the proceeds of bonds. In the former case, the amount of expenditure is limited by the appropriation therefore made by the Board of Estimate and Apportionment; a Board consisting of the Mayor, the Comptroller, the President of the Board of Aldermen, and the President of the Tax Department, and which has the power to fix the several amounts to be raised annually by taxation.

The amount of expenditure out of the proceeds of City bonds is in general limited by the act authorizing the issue of the bonds, for without an enabling Act of the State Legislature no City bonds can be issued for any purpose.

In case a street or avenue has once been paved and the expense thereof assessed upon the benefited property, the cost of any repaving which may be found necessary is paid out of general taxation, or out of the proceeds of bonds issued for the purpose.

Owing to the limit placed upon the length of this paper, and which

has already been over-stepped, it has been possible to give only a very general summary of the organization of the City Government. To some of the general statements, exceptions, created by special statutes, would upon an exhaustive examination be found to exist. To enumerate these exceptions, would however serve no useful purpose, as they in no wise affect the general scheme upon which the municipal government is organized.

GOVERNMENT OF PROVIDENCE, R. I.

BY J. HERBERT SHEDD, CITY ENGINEER.

OUTLINE OF ORGANIZATION.

The government of the City of Providence is organized as follows:

Mayor—elected by the people by a majority vote.

Board of Aldermen—one from each ward—elected by property voters—plurality vote.

Common Council—four from each ward—elected by property voters—plurality vote.

All for one year. Ten wards in the City of Providence.

The city officers, with the exception of City Treasurer, Overseer of Poor, Harbor Master, Commissioner of Public Works and City Engineer, are elected by the City Council or Board of Aldermen; to serve one year.

The City Treasurer, Overseer of Poor and Harbor Master are elected by the majority of the people, for one year.

The Commissioner of Public Works is appointed by the Mayor under approval by the Board of Aldermen.

The City Engineer is appointed by the Commissioner of Public Works.

PUBLIC WORKS.

The Commissioner of Public Works has control of the Public Works Department, which comprises the Water Works, Sewer, Highway, Bridge and City Engineer's Departments. The Commissioner of Public Works has charge of the construction and maintenance of all work pertaining to these departments. The Commissioner of Public Works appoints the City Engineer who is a "City Officer" and not an employe of the Public Works' Department, and assistant engineers, the salaries of the same to be fixed by the Commissioner subject to the approval of the Board of Aldermen. The Commissioner appoints all superintendents, inspectors and employees of the several departments, for the execution of work, and fixes the salaries of the same up to one thousand dollars, above that sum the City Council must

approve his recommendations to validate them. The Commissioner is required to advertise when not otherwise authorized by the City Council and contract for material or work to be done after the same has been ordered by the City Council.

QUALIFICATIONS.

The appointees are not required by law to have any professional qualifications.

TENURE OF OFFICE.

The term of office of the Commissioner of Public Works is three years. The term of office of the City Engineer and his assistants expires with that of the Commissioner making the appointment. The other employees of the Public Works Department have no stated term of office. The office of Secretary to the Commissioner is created by the General Assembly, but the appointment and removal is under the control of the Commissioner of Public Works.

METHOD OF ORDERING PUBLIC WORK.

The construction work on Highways, Water Works, Sewers and Bridges is performed under the direction of the Commissioner of Public Works, acting under resolutions of the City Council. The maintenance of repairs on Highways, Sewers and Water Works is kept up without an order from the Council. On bridges a sum not exceeding seven hundred and fifty dollars per year for each draw bridge and five hundred dollars per year for other bridges is allowed for maintenance. An ordinance of the City Council is necessary to exceed that sum.

The resolutions of the City Council ordering work performed generally state that the same shall be done in accordance with the plans and specifications of the City Engineer, who has immediate supervision of all new work.

The City Council provides each fiscal year an appropriation for every department. For Water Works and Sewers an appropriation for both construction and maintenance is separately provided. For Bridges, Highways and City Engineer's Department one appropriation is severally made. An addition to an appropriation is obtained by ordinance of the City Council, the funds being taken from unexpended money in the treasury.

The money for the support of the city government is obtained by taxation on real and personal property, water rents, court fines, licenses, interests on deposits, rents from city property, etc. The City of Providence is allowed by statute to borrow money by notes or bonds to an amount not to exceed three per cent. of the City's valuation and can only borrow in excess of that amount by permission of the General Assembly of the State.

GOVERNMENT OF BUFFALO.

BY E. B. GUTHRIE, DEPUTY CITY ENGINEER.

Synopsis of the Charter of the City of Buffalo, Which will go Into Effect January 1st, 1892.

LEGISLATIVE.

Common Council is composed of two bodies viz: The Board of Aldermen consisting of twenty-five members, one elected from each ward with term of two years, and the Board of Councilmen, consisting of nine members elected by the city at large with a term of three years. All action must originate in the Board of Aldermen, while the Board of Councilmen only approve thereof or return to the first Board for further consideration.

CITY CLERK.

Appointed annually by the Common Council.

EXECUTIVE, ETC.

Mayor:—The Mayor is elected for three years.

Finance:—The Comptroller and Treasurer are each elected for three years.

Assessment:—Five Assessors are elected for five years, one annually.

Law:—The Corporation Counsel is elected for three years.

Police:—The Mayor and two Commissioners appointed by him for six years form Board.

Health:—Health Commissioner appointed by the Mayor for five years and the Board of Health consists of the Mayor, Health Commissioner and President of the Board of Public Works.

Fire:—Three Fire Commissioners appointed by the Mayor for six years, no more than two to be of the same political party.

Public Works:—Three Commissioners with term of three years, one elected, two appointed by the Mayor, but both cannot be from the same political party.

Parks:—Fifteen Commissioners appointed by the Mayor for six years without salary.

Instruction:—Superintendent elected for three years.

Poor:—An Overseer elected for three years.

Municipal Court:—Two Judges elected for six years.

DEPARTMENT OF PUBLIC WORKS.

This Department is under the entire charge of a Board constituted as described above and the department is subdivided into four Bureaus, the officers and employees of which are appointed by the Board of Public Works. The Bureaus are as follows:

Bureau of Engineering:—Having charge of the construction and re-

pairs of sewers, pavement, bridges, docks, and sidewalks, locating and grading streets. The chief officer of this bureau being the Chief Engineer.

Water Bureau:—Having charge of the construction and maintenance of all work pertaining to the water works. The chief officer of this bureau is the Water Superintendent. The Water Bureau however remains in charge of the present three Water Commissioners until January 1st, 1893, when their term expires.

Bureau of Streets:—Having charge of the cleaning of streets, removal of garbage, keeping streets free from encroachment, cleaning sewers, inspection of gas and electric lights, and conduits of all kinds. The chief officer of this bureau is the Street Superintendent.

Bureau of Building: —Having charge of the construction and repair of all buildings in the city. The chief officer of this bureau is the Superintendent of Public Buildings with three inspectors who shall be practical building mechanics of not less than five years experience.

The Board of Public Works may recommend any work to the Common Council with or without plans and specifications, and the Common Council may order the work done or may order plans and specifications furnished with or without estimates or bids from parties to do the same. The Common Council may order any work with or without recommendation of the Board of Public Works, but when so ordered a contract shall be made by the Board except when the latter is authorized to do the work itself. The Board may, on the order of the Common Council, enter into contract for not exceeding five years, for cleaning the streets. No extension of the water works to be made except on the recommendation of the Board.

APPOINTMENTS.

Appointments and removals in the Department of Public Works to be made by the Board and all appointments below the heads of Bureaus, excepting those of a fiduciary character will be under the Civil Service rules if the present system is retained by the Mayor in forming the classifications for next year. No provisions for any professional qualifications of appointees in the Department of Public Works other than as specified.

TENURE OF OFFICE.

The charter provides terms of office only for the commissioners themselves, while their appointees are subject to removal at any time.

METHODS OF ORDERING WORK.

Cross-walks, sidewalks, culverts, sewers, receivers, wharves, piers, canals, slips and paving are to be paid for by local assessment. City Hall, markets, bridges, reservoirs, wells and fountains to be paid for either by general or local assessment. Repairs of paved streets and public sewers to be made from the general fund, and such repairs to be

made by the Board without order of the Common Council, and the Board shall employ labor and purchase materials therefor. No expenditure of $500 dollars or over to be made by the Board without consent of the Common Council; for expenses in excess of this the Board shall publish a notice twice a week for two weeks in the official and two other daily city papers inviting proposals and then contract with the lowest responsible bidder. When a street is to be paved, plans and specifications shall be prepared for each kind of pavement, for laying which specifications have been filed by the Board. The latter shall advertise for bids and report to the Common Council. After thirty days and within sixty days, the Common Council shall determine which kind shall be used, and in case no majority petition for a special kind shall have been presented, the Common Council shall declare by notice its intention to order the street paved with any kind it may select. When expense of paving exceeds $500 it shall not be ordered except

1st. On a three-fourths vote of all members elected to Common Council and after publishing notice of intention three times a week for three weeks.

2nd. Unless petitioned for by a majority of resident owners representing at least two-fifths of all feet frontage.

No work, except paving, which shall exceed $500 shall be ordered except by two-thirds vote of Common Council and after publication in six successive issues of the official paper and one other daily paper, of notice of intention to so order. The money for work to be paid for out of the General Fund is to be raised by annual general tax and based upon the estimates of the Board, all work to be paid for by special local funds are to be provided for by assessments on the property benefitted, which latter works include sewers and pavements, for which the city pays no portion unless it holds property improved by the work. The assessment rolls for local work are held by the Assessors for ten days from time they publish notice that they are on file in their office for inspection, then they go to the Corporation Counsel who examines into their regularity, then, if regular, they are delivered to the City Clerk who publishes notice in five successive issues of the official papers that objections may be filed thereto within ten days, if no objections are filed, the rolls become confirmed by limitation; if objections are filed the fact is communicated to the Common Council and the latter then considers the objections, confirms, annuls or refers it back to the Assessors for a new assessment. Upon confirmation of an assessment roll it is delivered to the Comptroller who publishes notice to that effect and that the same will be delivered to the treasurer in two weeks thereafter, upon receipt of the roll by the treasurer notice is published in five successive issues of the official paper

that payments may be made thereon at any time within a month without addition of interest and that thereafter interest will be added at one per cent. per month until returned to the Comptroller for enforced collection, into details of which it is impossible to enter here. The treasurer does not advertise a roll until notified that the work has been commenced. An assessment is a lien upon property soon as the roll is published by the Treasurer. When any local assessment exceeds $5,000 and in every case for paving, payments can be made in five annual installments, the last four bearing five per cent. interest. Provision thus having been made for payment of the work the latter is carried out by the Board.

GOVERNMENT OF PHILADELPHIA.

BY PROF. DWIGHT PORTER.

Under the provisions of the Bullitt bill, which applies to all cities of the first class, so called, in the Commonwealth of Pennsylvania, and which came into effect in April, 1887, executive power in the city of Philadelphia is vested in the mayor and in nine departments, as follows:—

I. Department of public safety.
II. Department of public works.
III. Department of receiver of taxes.
IV. Department of city treasurer.
V. Department of city controller.
VI. Department of law.
VII. Department of education.
VIII. Department of charities and correction.
IX. Sinking fund commission.

The mayor is chosen at the municipal election, and holds office for four years, but is not eligible for the next succeeding term.

The department of public safety, and that of public works, are each under the charge of one director, who is nominated, and with the advice and consent of the select council is appointed, by the mayor. These directors hold office during the term of the appointing mayor.

The department of charities and correction is in the charge of a president and four directors, all of whom are appointed by the mayor; but their term of office is five years from date of appointment, assuming good behavior.

The receiver of taxes, the city treasurer, the city controller, and the city solicitor, are at the head of their respective departments. They are elected, and hold office for a term of three years.

The department of education and the sinking fund commission were not disturbed by the Bullitt bill.

The mayor is *ex officio* a member of the various boards, such as the board of health and others, excepting the board of building inspectors, and may vote and otherwise participate in the proceedings of such boards. By written order, transmitted to the select council and giving his reasons therefor, he may remove from office any head of department or other officer appointed by him. His salary is by city ordinance fixed at $12,000 per annum.

By the director of the department of public safety is exercised supervision and management of all matters relating to the public health, to the fire and police force, fire alarm telegraph, erection of fire escapes, and the inspection of buildings, boilers, markets, etc. Attached to this department is the board of health, composed of five members, nominated by the mayor and confirmed by the select council for a period of three years. The director of public safety is *ex officio* a member and president of this board, and, subject to its orders, may appoint and control all its subordinate officers and employes. The board of building inspectors is also attached to the department of public safety, and the three members of the board—practical bricklayers and carpenters—are appointed by the director, and act under his supervision and control. The salary of the director of public safety is $7,500 per annum.

The director of the department of public works is entrusted with supervision and management of the city water-works and gas works; the supply and distribution of water and gas; the construction, maintenance, cleaning and lighting of streets, alleys and highways; the construction and repair of bridges and of public buildings, excepting those used for educational or police purposes; public squares; surveys, engineering, sewerage, drainage, and dredging; and all matters relating to the highways, footways, wharves and docks of the city. Certain previously existing special acts regarding public grounds and buildings were not affected, however, by this bill. The city is divided into survey districts, the district-surveyors being appointed, subject to approval by the select council, for terms of five years, by the director of public works, and performing their duties under the direction of that department. The director of public works receives an annual salary of $7,500.

Directors or chief officers of departments appoint all subordinate officers and clerks, and by written order giving their reasons, which must be other than political, may remove or suspend such appointees. Appointments of officers and other employes, and promotion of subordinate officials must, however, be based upon competitive examination: but assistants of the city solicitor, assistants or laborers employ-

ed for special or temporary work, and professional experts, are excepted from this requirement. Personal solicitation of the appointing power in favor of any candidate, by any person, disqualifies the candidate for competing, for one year, at any examination or appointment.

Contracts for public improvements are to be based upon estimate of the whole cost, furnished through the department having charge of the improvement, and no bid in excess of such estimate is to be accepted. In case of contracts for improvements, the cost of which is to be paid by assessment upon property abutting or benefited, the contractor must look, not to the city, but to the assessment for his compensation.

Councilmen, officers, and employes in general of the city, are not to be interested, directly or indirectly, in contracts for work to be done for, or material to be furnished to the city, under penalty of forfeiture of office. The receiving by an officer or employes of any department of a gift, fee, or any pay for official services other than his regular salary, except by written consent of the director of the department, is forbidden, under penalty of dismissal from office; as is also participation, even by presence, in any political convention.

GOVERNMENT OF THE CITY OF PARIS, FRANCE.

BY HENRY D. WOODS, C. E.

The government of the City of Paris differs considerably from that of the other cities of France, from the fact of its being the Capital and seat of the Central Government. For this reason it is more directly under the control of government officials, both in the matter of its finances and police, as well as in that of its public works.

In a general way the country is divided into thirty-seven thousand "Communes" so called, which are the units of government in France. Each Commune is presided over by a "Maire," appointed by the President of the French Republic, from among the members of the Municipal Council of the Commune, which is elected by popular vote. The Maire has from one to three "Adjoints" or assistants, according to the population, who represent him when absent, or in press of business. These offices are gratuitous.

The Maire represents the executive power of the Commune, he represents the law in all civil acts, performs all marriages, and makes out all certificates of births, deaths, etc. He is agent of the General Government for the execution of all measures issuing from it, and is a delegate of the judicial authorities in the maintenance of peace and order. At the same time he is agent of the Commune to look after its interests. He has the appointing of a certain number of officials.

The Municipal Council discusses all measures to be taken for the management of the Communal properties, and the carrying on of its administration. It passes all appropriations, ordinances, etc. The Maire is President of the Municipal Council. The members are elected for a term of six years, and renewed by halves. There are from ten to thirty-six members, according to the population plus one additional for each "adjoint."

Each of the eighty-seven Departments of France is governed by a Prefect appointed by the President of the Republic. He represents the General Government, and has charge of all the interests of the Department, which he controls through the Sub-Prefects. He is assisted by a Council of Prefecture, appointed by the Government. Each year the Prefect visits the different Communes of his Department, and makes a report to the Minister of the Interior. He has the power to suspend a member of a Municipal Council in certain cases.

The Department of the Seine, in which Paris is situated, is the smallest of all the Departments, and contains but two other cities, the Sub-Prefectures of St. Denis, and Sceaux.

The "Prefect of the Seine" is in reality the "Maire" of the City of Paris, as the term is applied to the other cities of the State.

The Municipal Council of Paris discusses the appropriations, and votes on them, but it can not by vote stop the credits or appropriations for carrying on any public service that devolves on the city to provide for. The Minister of the Interior has the power to insert in the appropriation order any omission of this kind that may occur.

The President of the Municipal Council of the City of Paris, is elected by the members, and simply presides over its sessions, and represents it on official occasions, but has none of the duties of a Maire to perform.

The City of Paris is divided into twenty "Arrondissements" each of which has a "Maire" with assistants appointed by the Prefect of the Seine, who attend to all the Civil Acts of the Arrondissment. Each of these Arrondissments is divided into four "Quartiers" each of which elects a member to the Municipal Council.

The Prefect of the Seine, besides having to look after the interests of the Department of the Seine, has also to supervise the finances of the City of Paris, the Municipal debt, taxes, elections, schools, public land and offices, municipal buildings, markets, cemeteries, highways, parks, water works, sewers, bridges, navigation and harbors of the river and canals, the pawnbrokerage establishment, and the relief of the poor.

Thus all the public works of the city are under the general management of the Prefect of the Seine. All estimates and bills for settlement for work, have to be approved by him, as well as by the Council.

All questions of public safety and order are under the management and control of the "Prefect of Police," appointed by the Government. His department is divided into three classes: *Political police* and the *public safety*, referring more directly to the general welfare of the country at large, and the *municipal police*, specially for the city. Under this latter head the Prefect of Police has to look after the public health: keep the civil peace, repress all crimes and misdemeanors; have a surveillance over all hotels, lodging, etc.; test all weights and measures; look after all markets, slaughter-houses, public vehicles; funerals; the fire department and general sanitation. Lately some of this work has been put into the department of public works.

The Prefect of Police has full control of his appropriations, and the Municipal Council has only to pass them as a lump sum. Owing to the importance of this department for the general public, the Government refunds to the city about one-third of the appropriation.

PUBLIC WORKS IN PARIS.

All the Cities of France may apply to have Government Engineers, from the "Corps des Ponts et Chaussees" detailed for service on their works, but the City of Paris, alone, is obliged by law to have all its public works carried on under their direction.

In 1854, Mr. Belgrand, Chief Engineer of the Ponts et Chaussees, was put in charge of the Water and Sewer Works of the city. About the same time Mr. Alphand of the same corps, was put in charge of the streets, parks, lights, conveyances, and in fact all the other public departments. Under these two heads were eight Division Engineers, of the Ponts et Chaussees, each having a section of the city to look after, who reported to each head, on that portion of the work that referred to his departments.

Mr. Belgrand died in office in 1878. Then his office as a separate one, was abolished, and all the departments were put in the hands of Mr. Alphand, as Director of Public Works, assisted by Mr. Huet, as Sub-Director. The present organization dates only from 1878.

Mr. Alphand died last December, and his place has probably been filled by promotion.

The Department of Public Works of Paris, comprises all the public work for the city above or below the surface of the ground. There are five divisions.

Public Ways and Parks, with adjoining buildings.

Collection and Distribution of Water.

Sewers, and the disposal of all refuse of human life.

Architectural Works.

Fine Arts, and the care of Historical Works.

The Sub-Director has also charge of the general accounts of the works, care of collection, plans and models, that belong to the city, the

oversight of the Municipal Observatory of Montsouri, and the control of the operations of the Telephone Co., Pneumatic Clock Co., and the various companies for distributing power about the city.

The Department of Public Works is divided into two secions:—the Interior Service that forms a part of the offices of the administration of the Prefecture, and the Active Service, including all outside work.

The Interior Service is divided thus:

First Division	1st Bureau	General Works.
	2nd "	Water, Canals, Sewers.
Second Division. HIGHWAYS.	1st Bureau	Contracts, Acquisitions, Expropriations.
	2nd "	Street-lines, Unhealthy Houses.
	3rd "	Streets, Parks, Lights.
Third Division ARCHITECTURE.	1st Bureau	City Buildings, Etc.
	2nd "	State and Depart. Buildings.
	3rd "	Book-keeping, Control, Verification.
FINE ARTS.	Orders, Competitions, Expositions, Festivals.	
	Care and Inventory of Monuments and Art Objects.	
HISTORICAL WORK.		

Active Service is subdivided as follows:

I. DIRECTION OF HIGHWAYS AND PARKS.

The Sub-Director, is Director of this Division and has charge of,

PLAN OF THE CITY.	One Curator. Three Head Geometers.	Central Section. Alinement Section. Topographic Section.
	Seventeen Surveyors.	
	Twenty-One Assistant Surveyors.	
	Six Draughtsmen.	
	Two Assistant Draughtsmen.	
	Thirty-three Chainmen.	
HIGHWAYS.	Twenty Highway Surveyors.	
SUPERVISION OF PUBLIC CARRIAGES.	One Chief.	
PARKS AND PLANTATIONS.	One Consulting Inspector, Director of the School of Arboriculture.	
	One Chief Gardener, Two Inspectors.	
	Two Curators for the Parks, One Architect.	

Public Ways, including: Street Cleaning, Lighting, Leases on Streets.

PUBLIC WAYS.	1st Div. Left Bank & Bois de Boulogne	One Chief Eng. P. et C.
		Three Ord. " " " "
	2nd Div. Right Bank & B. de Vincennes.*	One Chief " " " "
		Three Ord. " " " "
CONTROL OF GAS WORKS, AND METERS.	One Chief Inspector and Three Assistants.	

*These are the eight Div. Eng. of the organization of 1854-1878.

II. WATER DEPARTMENT.

Canals and Water Supply.	One Engineer in Charge.
Maintenance of Conduits.	One Inspector.
Distribution of Water.	One Inspector. Two Sub-Inspectors.
Pumping Plant.	One Inspector.

III. SEWER DEPARTMENT, ETC.

	One Chief Engineer, Actually Chief Eng. P. et. C. One Consulting Eng., " Insp. Gen. P. et. C.
Sanitation of Dwellings.	One Inspector P. et C.
Construction and Cleaning Sewers and the River Bievre.	The Eight Div. Engineers. One Ordinary Engineer, P. et C.
Sewerage Irrigations.	One Ord. Eng. P. et C. One Inspector P. et C.

IV. QUARRIES.

One Chief Engineer acting as Inspector of Quarries.
One Ordinary Engineer acting as Special Engineer.

V. ARCHITECTURE.

Control and Verification.	One Head Controler. Two Sub-Controlers.
Maintenance of Public Buildings.	Twelve Architects.

Once a week there is a meeting of the Council of Engineers under the presidency of the Prefect of the Seine, to deliberate and advise on the works proposed by the different engineers, connected with the several departments. This Council consists of:

The Prefect of the Department of the Seine.

The Director of Public Works.

The Consulting Engineers.

The Chief Engineers of the Highways.

The Chief Engineers of the Department of the Seine.

The Chief Engineer of the Quarries.

The Chief Engineer of the Water Works.

The Chief Engineer of the Sewers.

The Division Engineers attend the meetings to give information in reference to their Divisions. The Section Engineers are called in when necessary.

All important work, whether emanating from the Department of

Public Works, the Municipal Council or the State, after being worked up and planned by the engineers, has to be approved by the National Council of the Ponts et Chaussees, before it can be executed.

APPENDIX.

The Engineering force of the Department of Public Works of Paris, is composed of two classes:

Engineers and Conducteurs of the Corps Ponts et Chaussees, detached from the government service and detailed to the Prefect of the Seine: they are paid by the city at the rate corresponding to the grade they hold in the P. et C., plus a certain amount for expenses or residence, varying with their work.

Municipal Engineers and Conducteurs, who are Civil Engineers, not connected with the Ponts et Chaussees. Their pay is similar to that of the other class, for the same positions.

Both classes are subjected to a tax for the pension fund of their respective corps.*

Placed under the orders of the engineers, are a force of conducteurs, inspectors, and foremen or overseers. Those taken from Civil practice have to pass an examination corresponding to the one passed by the P. et C. men of the same grade, and the overseers have to pass a second one before they can be promoted to the grade of inspectors.

On the 31st of December, 1889, this force stood as follows:

INTERIOR SERVICE.	112 Persons, divided into 11 offices,	received	$87,400
	14 Auxilliary Agents . .	" "	5,670
ACTIVE SERVICE.	877 Persons	" "	$564,570
	286 Auxilliary Agents . .	" "	108,120

There were twenty "Commissaires Voyers" or highway surveyors, and twenty assistants, one each for each Arrondissement, with office at the Mairie. They examine all applications for buildings, signs, lanterns, etc., all butcher shops, and similar places, unhealthy lodgings, estimate costs of damages for takings of lands and buildings for street improvement, etc. Salaries from $520 to $2,600 per annum.

The Geometers or Surveyors of the plans of Paris who make all land plans and studies for new streets and alterations in the old one, and give all street lines. Salaries of Surveyors and Draughtmen $900 to $1,100.

Salaries of Assistant Surveyors and Draughtsmen $600 to $800.

Salaries of Chairmen $420 to $520.

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*It might be well to state here that all the employees of the city, and in fact the employees of all Contractors and Manufactories are taxed in the same way for a pension fund. The tax is in the form of a per-centage of the wages, which is retained, on pay day. The City, Contractor, or Manufacturer paying also into this fund a certain amount, proportional to the pay rolls.

DISCUSSION.

President Stearns:—I will say with reference to the subject of Mr. Moore's paper that there is another paper relating to the government of St. Louis in the North American Review for November, 1891, written by the Mayor of the city, and he reaches conclusions similar to those which Mr. Moore has reached. He says, for one thing:

"The charter was most carefully prepared by eminent citizens, many of them of national reputation, and while it is necessarily defective in respect to the absence of the judicial branch, it is nevertheless confidently believed to be the best city charter in the land."

In another place he says:

"In St. Louis it (the charter) has been tried, and it is confidently believed that with a very few modifications which experience and time will accomplish, the problem of the government of cities has been solved in its present charter."

I will read another quotation relating to the board of public improvements. He says:

"In addition, there is another check upon the reckless or extravagant appropriation or expenditure of public money for street purposes, in the fact that the legislative branch cannot pass an ordinance for such purposes unless it is recommended by the board of public improvements, which is composed of five members appointed by the Mayor, and a president who is elected by a direct vote of the people."

This shows an agreement in two papers written from an entirely different stand-point.

All of the papers are open to discussion, and Mr. Moore will no doubt be ready to answer any questions that may be asked him.

Mr. L. F. Rice:—I should like to ask Mr. Moore, if at the inception of this departure from the old system, there was any conflict or attempt at conflict between the previously existing methods of conducting work, or those who previously did the work; (that is to say, the leaders in the political organizations) and the new organization which was divorced from them;—whether there was any attempt to contest the new order of things, and if so, what the result of that attempt was?

Mr. Moore:—There was no contest except in determining the vote by which the new charter was passed. There was some attempt to contest that. The old county court, whose jurisdiction over city affairs was to be done away with, died hard, and the divorce of the city and county was on the part of the latter not gracefully accepted. The previous experience had been that the county received very large benefits from the taxes paid by the city. The county roads were then built and improved by taxes raised in the city. Since that time road build-

ing in the county has almost ceased. But after the vote was finally decided there was no further contest, and the new order of things went into effect with the utmost harmony and without any clashing whatever. There was a little difficulty in interpreting some of the clauses of the city charter, owing to the fact that it was prepared in so short a time that its provisions were not quite as well digested as they should have been. But all of these difficulties were soon harmonized by judgment of the city counsellor, who was authorized to settle such difficulties, and the new machinery moved on without friction.

MR. J. T. DESMOND:—I would like to ask Mr. Moore if he did not find some trouble, as a member of the board, in letting contracts to the lowest bidder. I notice the same thing in the New York charter. Don't you think that might make some trouble, that an irresponsible party might be the lowest bidder?

MR. MOORE:—No, sir: I believe not. Every bidder is required to deposit security that he will execute the contract, and give a proper bond. If he fails to do that his money is very promptly covered into the treasury, and the experiment is not often repeated. The system of letting to the lowest bidder I think has been an entire success. Of course it has not always secured the most desirable contractor. Occasionally one would have a contract in his department given to a man who should, perhaps, have been in the penitentiary. But it was the commissioner's fault if he did not get the work properly done. He had ample power to get all that was nominated in the bond, and if he did not get it, he only was to blame. There was practically no difficulty in doing it.

The principal difficulty under the old regime in the matter of contracts was a very vicious system under which the work was awarded at prices lower than it could be honestly done for, the contractors trusting to a lax inspection, to bring them off whole. But few inspectors were then provided for and those few were largely the appointees of the council committees. But under the new system the commissioner appointed his own inspectors, and no work was allowed to be begun until sufficient money to pay for the inspection had been provided. At first there were a few contractors rash enough to undertake work on the old basis, but after having the money due them prorated by the city treasurer among their creditors, they were more careful. After that the work was taken at prices for which it could be honestly done, and carried out accordingly.

MR. DESMOND FITZGERALD:—The magazines for the last three or four years have been pretty well filled with articles in regard to the conduct of municipal affairs. I have not, however, seen many articles by engineers, and I should like to see a few. From their position and experience they are particularly fitted to throw light upon the subject.

Among all the articles that I have read that by President Eliot in the Forum, seems to me the best. It is almost superfluous to say that it is clear and logical. There is only one point, perhaps, in which it is a little defective. The diagnosis is admirable but the remedy is hardly outlined. He says that the reason that our city governments have been failures, as a general rule, is that the charters have been founded on the old order of things, on the old town form of government, and that we have outgrown that kind of thing entirely. He goes on and analyzes the different departments, and shows that now the great departments, such as sewers, streets, water, the lighting, have grown to be of such importance, that it is requisite that they should be brought under the charge of men trained in these particular specialties. I do not know that I can do better than to quote some of his own words on this very subject. He says:

"It is observable that the failures of the Democratic form of government have occurred chiefly in those matters of municipal administration which present many novelties and belong to the domain of applied science: Such as the levying of taxes, the management of water supplies and drainage systems, the paving, lighting and cleaning of highways. All these matters require for their comprehension and proper management a high degree of scientific training, and all of these require the continuous execution through many years of far-reaching plans."

Now it seems to me if President Eliot had had twenty or thirty years experience in city government he could not have stated the case better. The patchwork system that our cities have been subjected to is one principal cause of failure; and that comes largely from lack of system in the tenure of office, insecurity of position, and its attendant evils. Particularly is this true in the administrative part of the work. Under the present system one man no sooner gets fairly trained to the needs of a department than he goes out of office. Another man then comes in with a lot of new ideas which are generally modified by experience. That is the way most of our governments have been handled. President Eliot goes on to say:

"I need not say that these departments can be successfully managed only by men who have received an elaborate training and who have labored continuously for years in one field. In the great European capitals these departments of municipal service are admirably managed by men trained in schools long famous, expressly for the planning and direction of such public works, and kept in service, like officers of the army and navy, during good behavior and efficiency."

Perhaps that accounts largely for the difference, at any rate in the outward aspect of things, in some of the European capitals and our own in regard to the conduct of some parts of the work. Mr. Eliot

thinks that tenure of office will not be more secure until the Mayor has a longer term, and that the heads of departments should be safe from arbitrary dismissals.

I think every one must have felt, in hearing these papers to-night, that there has been a great difference, looking at it broadly, in the method of administration. In the one case we have a complex system with a series of little details lacking in breadth and comprehensiveness: and in the St. Louis case as it seems to me we have a scientific plan. It is a great deal like a fine work of art, the better it is the simpler it is. The details have been subordinated, and everything is under control of men selected for their ability to accomplish the work.

Then I wish to call attention especially to the great strength of this board of experts, consulting together on matters of importance. Any head of a department can at any time call for the united judgment of the whole board, and that gives a great deal of strength to the administration of an ordinance or a law, or the planning of a work—that the united judgment of all these experts in the different departments has been called upon, that it seems to me must have a great deal of influence in the community.

Mr. H. H. Carter:—I should like to get from Mr. Moore a little more information as to the way in which the different commissioners carry out their work. For instance, this board of public works, which is composed of a president and five commissioners, among whom we find the street commissioner, has a very large amount of work to do. Now I should like to know from Mr. Moore whether, for instance, the street commissioner has a permanent force of day laborers who attend to the ordinary repairs of streets, and a permanent force of sewer laborers who attend to the cleaning out and the ordinary construction of sewers, small sewers and man-holes; or whether this board has so arranged its work that all of the work is done by contract and the board simply carry out the execution of the whole work. In other words, whether in St. Louis everything is done by contract, or have they a number of day laborers who attend to a certain amount of routine work?

Mr. Moore:—In answer to that I would say that everything that can be definitely specified and measured is done by contract. The paved streets are swept by contract. The removal of garbage is done by contract. The streets and alleys as well as sewers and man-holes are all repaired by contract. In fact, almost the only thing which the city does by day labor is the cleaning of the macadam streets, the extent of which is so uncertain that it cannot easily be specified. But wherever it is possible in the nature of things to definitely describe and specify the work so that its amount can be ascertained and measured, it is done by contract; and there is entire unanimity of opinion that this is the

best way to get satisfactory results whether in point of economy or of excellence of work.

MR. L. F. RICE:—I should like to ask Mr. Moore if the old system, the system which was in vogue twenty years ago when I was somewhat acquainted with St. Louis, still continues. That is, the manner of paying for public work. At that time a contractor for a sewer, for instance, would receive his pay in vouchers in some form—I do not remember the precise title that was given them—by which he collected the payment for the sewer from the abuttors on that sewer, and not directly from the city treasury. I would like to inquire whether that method is still in vogue or what has been substituted for it.

MR. MOORE:—Yes, sir; it is still in vogue. The sewer system aside from the strictly private sewers, is divided into two classes: the class of "public sewers," which embraces the main trunks or drainage channels, and the class of "district sewers," which are built for the drainage of particular districts. The public sewers are paid for out of the general revenue, but the cost of the district sewers is borne by the property drained, and is assessed upon each lot in the district in the proportion that its area bears to the area of tne whole district. At the conclusion of the contract the cost is ascertained by the sewer commissioner, and then subdivided over this area by the special tax department, which, as I stated, is under the charge of the president of the board. These bills of special assessment, which are a lien upon the property and draw a high rate of interest after presentation, are given to the contractor and he collects them. If the parties do not pay he sues them, and the courts have uniformly sustained the bills. They are most admirable security for the borrowing of money, so that there has been no difficulty in finding contractors who, on the strength of such payment as this, will undertake work involving several hundred thousand dollars, for not a cents worth of which did they get any pay until the whole work was completed, and then only in these bills of special assessment.

I would say also that this same system holds in the original construction of streets, except the grading. The grading and the preparation of the earth bed upon which the pavement rests is done by the city out of the general revenues. After that the cost of the pavement itself, the macadam or granite or wood or whatever it may be, is paid by special assessment, which, however, is levied in proportion to the front foot bordering upon the street, and not upon the area as in the case of the sewers.

MR. HENRY MANLEY:—I would like to ask Mr. Moore if the works to which he referred as having been done by the city in such an admirable manner, the work in the alleys and the work upon the elevated railroad, were done by the city by contract or day labor?

MR. MOORE:—The re-paving of alleys is done by contract. The moving of water pipe referred to was done by the "street service" force, of the department, the special duties of which are to repair breaks in pipes, and see to the condition of fire plugs, etc. This force is composed almost wholly of men who have been long in the employ of the department and have become expert in the work. They may be treated as a body of skilled laborers. They are not common laborers picked off the streets, but are a permanent force of skilled men entirely under the control of the water commissioner.

MR. F. W. HODGDON:—I would like to ask Mr. Moore this question. You said your work was done almost entirely by contract. Do you mean that you make special contracts for each individual item of repairs, or do you have a general contract, under which if a place gives out in a street or sewer, you send the contractor there and pay him an agreed price for the amount of work he does, by the cubic yard, or otherwise?

MR. MOORE:—The system is this, again illustrating by the case of the sewers. At the beginning of each year what is called the "annual repair contract" is let. The amount of the repairs for the ensuing year are estimated as well as they can be, as a basis simply of comparison of bids. Bids are then solicited for repairs of sewers wherever they may occur; so much for brick work, so much for pipe of this class and that class, for inlets and for excavations, all itemized. After this contract is awarded, if any break of any kind occurs in the sewers, the repair contractor is notified to go there and fix it, which he does under the directions and under the inspectors of the sewer department, and when he gets through his bills are figured up on the basis of his annual contract. The repairs of sidewalks and of alley paving are done in the same way, under an annual contract at certain prices which are fixed by competition. At the outset I was somewhat sceptical as to how this method would work, but after experience with its operation I found that it worked well in all respects, and that there was no difficulty in getting the work done promptly and well.

MR SIDNEY SMITH:—I should like to ask Mr. Moore if, in the creation of the municipal engineering council, the president of which is elected by the people and the other five commisioners appointed by the Mayor, the charter provides that any special professional qualifications shall pertain to the candidates. I see that they have had several of those boards. The first one had five gentlemen appointed who had received an engineering training, and it was a question in my mind whether the subsequent boards had continued in the same line or whether the charter required them to continue in the same line.

MR. MOORE:—The charter does not require that any of them shall be engineers, except in the case of the water commissioner. The ord-

inance organizing the sewer department, passed in pursuance of the charter, also requires that the sewer commissioner shall be an engineer. But with the exception of the water commissioner and the sewer commissioner there is no requirement of this kind. The practice, in the matter of the president of the board, has been to elect only a civil engineer. Col. Flad was elected for as long as he would serve, and he resigned only when the work became too onerous and he could stand it no longer. I think the general sentiment in the city is that no man is fit to occupy that place unless he is an engineer, although that is not required in the city charter.

Mr. H. A. Carson:—I would like to ask Mr. Moore how it is that the nomination of the president of this board of public improvements is made. What is the manner of nominating?

Mr. Moore:—He is nominated by the usual nominating machinery, which does not always produce the best results. But, fortunately for the city of St. Louis, the political parties are so evenly divided that it is very risky for either of them to put up a bad man. If they do he is pretty certain to be snowed under, because the scratcher is very active and puts him down. I suppose that if the city were differently situated and the parties not so evenly divided, we could not count on getting as good men. But in the case of Col. Flad, he was elected almost by acclamation; that is, his nomination required no effort and no effort was needed to elect him. It was generally conceded that he was the best man, and he was always put in by an overwhelming vote, and would have been elected so long as he would consent to run.

Mr. W. E. McClintock:—There is one point that has not been touched on this evening, and that is the question whether they have in St. Louis the same class of people that we have here, a class of adopted citizens, who claim the right of saying how work shall be done. They certainly object to contracts in any form, shape or manner. The question in my mind is what is done with this class of people who object to contracts of the smallest kind and who really care little how much any work costs. Do they in St. Louis have a class of this description who want to break up the contract system, and if so how you dispose of them?

Mr. Moore:—The only class of adopted citizens who act in any organized or united way, is the Germans, and their voice has always been for good government. They are firm allies of good government in every way. In regard to the contract system, there have been rather feeble and unsucessful efforts at times to do away with it in regard to cleaning the streets, that is the sweeping of the granite and wooden paved streets, which are swept by contract. Occasionally the municipal assembly has made it a condition of the appropriation that the streets should not be swept by contract. But it has never lasted but

a few months. The results obtained for the money were so meagre as compared with those that could be obtained by contract that parties interested were always glad enough to go back to the old system by which they got so much more for their money.

Mr. Albert H. Howland:—The cities of New York and St. Louis have been mentioned, and I notice one particular in which their charters very strongly contrast. In the case of St. Louis we are told that the charter was framed by its own citizens. In the case of New York it is said that the Mayor is elected at general election and is removable by the Governor, also that the powers of legislation reserved to the city are very small. It appears that the powers and duties of its officers are very minutely prescribed by the statutes of the State. I cannot say what difference in results has been due to these conditions, but the contrast is striking and the difference is fundamental.

Mr. Smith:—There is one question I have been requested to ask of Mr. Moore, and that is whether the Mayor, in making the appointments which he does at his third year—whether he appoints the five commissioners at that time or whether he only has the appointment of some of them, so that their terms should be alternating.

Mr. Moore:—He appoints the whole five at the beginning of his third year.

Mr. Smith:—He is supposed to have paid all his political debts at that time, I presume.

Mr. Moore:—The creditors have become worn out and gone into other business: they are not so importunate at the end of two years as they would have been the day after election.

Mr. E. P. Adams:—It occurs to me that one reason why the contract system in St. Louis is so favorably thought of is that the expense is assessed upon the abuttors in almost every case. The abuttors are very careful therefore, to see that the work is done in the most economical manner, by contract, which is well known to be the least expensive for certain classes of work.

Mr. Moore:—I think that does have a great deal to do with it.

Mr. E. P. Fisk:—There is one question that has not been touched upon here. I should like to ask Mr. Moore in regard to taxation in St. Louis. There are so many special taxes there, taking them in the long run, does it amount to more per capita than if the city did the work and paid for it itself?

Mr. Moore:—Well, that is difficult to say. Of course the amount of money spent would be the same in either case if it were done by contract. The advantage is that if the property benefited pays for it, whenever people are willing to pay for an improvement they get it. But if it is paid out of the general revenue, it then becomes a scramble as to who shall get the benefit of it. A man might want his street

paved or his property drained, but if not sucessful in the scramble might not have it done during his natural life. Whereas by the other system, whenever he is willing to pay he gets the work, and if he does not get it, it is his own fault.

Mr. Fisk:—What is the rate of taxation in St. Louis?

Mr. Moore:—I believe it is a little less than two per cent., with the probability that it will be reduced the next time the rate is fixed. I would say that the city is without any floating debt, that it has money in the treasury to pay all its obligations as they mature, and is in danger of having a surplus.

Mr. E. W. Howe:—Is that two per cent. in addition to the amount assessed on the abuttors for public improvements?

Mr. Moore:—The two per cent. is what is raised by the city and paid into the public treasury. The other assessments are not paid into the public treasury at all. They are paid directly to the holders of bills of special assessment.

Mr. A. F. Noyes:—I should like to ask you the question if, in the case of repairs on pavements or the re-paving of a street that has once been paved and paid for by the abuttors, the cost of repair and re-paving is assessed on the property again or paid out of the general fund?

Mr. Moore:—If it is simply a repair, the maintenance of the existing pavement, it is paid out of the general revenue. If it should amount to re-construction it may be assessed again upon the property. For example, certain streets which formerly were paved with macadam were torn up and paved with granite at the cost of the property benefited. There is no limit to the number of times it can be assessed where it amounts to complete re-construction, and is not simply repairs in the ordinary sense.

Mr. Howe:—How does the valuation compare with the actual value of property in St. Louis, the valuation upon which this assessment is made?

Mr. Moore:—I am informed by the city comptroller that property is assessed at about three fifths of its market value.

Mr. A. H. French:—I would like to ask Mr. Moore if it is not sometimes the case that a public improvement is of such a character that it should be paid for partly at the general expense and partly by special assessment? As I understood him, the cost of public improvements was entirely assessed on the estates benefited. Another point that occurred to me was that the contractors, as I know them, are not oversupplied with capital, and that if they were required to wait until their work was finished before getting any payments, and then be obliged to accept bills on estates, the work must cost considerably more than it would otherwise do; and whether or not that method of paying for improvements is not probably costing the abuttors more

than it would if the expense was paid first by the city and then assessed.

MR. MOORE:—I will say there is one important qualification as to the limit of assessment, and that is in regard to the work done in street improvements. As to these the charter requires that the total assessment shall not exceed twenty-five per cent. of the assessed valuation of the property. If it does, the remainder is made up from the general revenue, for which the city makes an appropriation. In regard to the other question, as to whether the cost of the work is raised by this method of special assessment, I think it is a very natural one. But as a matter of fact the cost is not raised. The contractors find no difficulty in borrowing money of banks and persons who have money to lend, to carry on their work. These bills of special assessment are considered a perfectly good security on which a man can borrow money almost without limit.

MR. FRENCH:—But he does not receive them until the work is finished.

MR. MOORE:—I know; but by agreement under which the bills when made are handed over to material men and other creditors, there is practically found to be no difficulty in carrying the work, and work paid for by special assessment is let at about the same prices as work paid for in cash. There is very little difference.

MR. FITZGERALD:—I think you stated in conversation that in St. Louis you have taken strips of land on each side of the street under the right of eminent domain and have disposed of that land afterwards by sale or lease for the best interests of the city. There has been a great deal of discussion in Boston recently on this very point. I should like to know if I am right.

MR. MOORE:—You are not quite right. I was speaking then only as to the condemnation of land for the purposes of a railroad. In such cases where part of a lot is taken the commission may require the railroad to take all of it, or if the railway company itself finds it necessary to take so large a part that it amounts to taking the whole it can elect to take the whole. In regard to the opening of streets, I do not know that this is the law. In opening streets, however, benefits are assessed as well as damages, and in levying these special assessments of benefits for the opening of a street the commissioners may take as wide a range as they please; they may go one mile or to the city limits, if they see fit.

MR. FITZGERALD:—It has been declared constitutional by your Supreme courts, hasn't it?

MR. MOORE:—I believe so.

MR. FISK:—Will Mr. Moore please tell us whether this two per cent. is levied on real estate or real and personal estate?

MR. MOORE:—Both, though of course there, as elsewhere, a large part of the personal estate escapes taxation altogether.

THE FINANCIAL STATUS OF THE ENGINEER.

ANNUAL ADDRESS OF JOS. LEON GOBEILLE, PRESIDENT, THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Delivered March 8th, 1892.]

If any man may be said to cause two blades of grass to grow where only one grew before, that man is certainly the Engineer, and, yet it is one of the anomalies of this life, perhaps the veritable "Irony of Fate" of which we hear so frequently, that some other man, or company of men, participates in the harvest, often to the practical exclusion of him whose trained intellect and patient research caused the increase. I know that it is popular to say that the mere possession of money is but a small part of life, and that our earthly reward consists in a conscious competency to do original work; but there is a prevalent suspicion that the Engineer is apt to look upon dividends, houses, lands, fine apparel and equipage, (so often placed on exhibition in this age,) with something more than a disinterested eye, if it happens that the *thing* which made these evidences of wealth possible, was the thought of his own brain, the embodiment of all that was best of his mind, perfected by experience and right conception; perchance, even the sacrifice for the time of many pleasant things of life, among which may have been the companionship of his wife and children, social amenities and needed rest and recreation. Do not misunderstand me; Engineers are not in want, their children are not begging for bread, but, of the wealth of the world directly traceable to the Engineer as its producer, a large percentage goes to the professional business man, and it is the concensus of opinion that the non-Engineer is falling heir to a constant unearned increment. There are many examples of so-called Engineers who have acquired great wealth. The majority of such never spent a day in Technical School, nor a week in the serious study of Science for its own sake, but being men of parts, possessed of a lively imagination, a glib tongue and an elastic conscience, they succeed by means of a deliberate looting of educated men. They steal brains under pretence of purchase, as if a lapidary should pay a dollar for a diamond because the miner had not the means for cutting it. The shrewd man of business *thinks* a great bridge can be built, or a cable laid, or the electric current utilized as a motive power, or otherwise, in some special line and then, by means of the best work of a dozen trained men, his wish becomes a practical reality—straightway he blossoms into a great engineer, representatives of the secular press, (yes, and of the technical press also, for he advertises,) interview him in regard to reproducing the drawings, full size of course, of the apparatus with which Archimedes proposed to move the world: his income is computed by the day,

so that ordinary Engineers can grasp the terms employed without resorting to higher mathematics, while the men who *made* this wonderful creature get a paltry increase in salary, or another position, according as he has, or has not, further use for them.

If we concede that the Engineer is not a money maker, *per se*, we ought to have an adequate reason therefor, and it is found in the very nature of his training: the boy has an inherited taste for mathematics and things of precision, and upon his advent at school, he enters a world of fascination, his tendencies and his opportunities unite, as by chemical affinity, and it needs but the spark of encouragement or emulation to set all his faculties in a blaze. Fortunately (or unfortunately) study in these lines, while it improves and quickens the perception and reasoning powers in a wonderful degree, it is only in that special channel —between the growth he experiences, and that required for money getting, there is a continually widening gap. Who remembers a boy that stood high in arithmetic who could increase his stock of marbles by playing with the poorest scholar in the class? Or of one at the head of his form in natural philosophy, who could not, inside of two days, have his new six-bladed jackknife reduced by successive swappings to a bare handle? The fact is that the boy whose likes are in the direction of those things necessary to engineering, if studious and conscientious, is furnishing the all-around-sharp-nobody-of-a-boy with marbles and jackknives during the entire school course and, worse yet, he keeps it up through life with the same stripe of boys of larger growth. This is not true of any other line of study, as is slowly coming to be understood. It is a significant fact that within the past month, at a mass meeting in Boston called to consider the short comings of our public school system, President Elliot boldly asked for the elimination of higher arithmetic from the Grammar School course and the substitution of some Language, because he said that the set of faculties improved by that study came into play for none of the ordinary demands of successful business life and citizenship, but were detrimental thereto. (I quote from the newspaper report). Can anyone say why the persistence in the work of intricate mathematical calculation and analysis should start a man at a tangent from a well-rounded, provident life? Unfortunately no formula has been deduced by which we can show why this is true, though it would be worth more than all the wealth of the Indies to be able to solve the problem and put it on the board before you: it is exceedingly difficult even, to define the difference existing between the faculties which create and those which conserve wealth, but, we can conceive it to be something like that which exists, psychologically speaking, between Perception and Sensation: *e. g.* mere speculation enters largely into the mixture used by forehanded men of business—not at all in that of the Engineer, for while the

Engineer is calculating whether his arch shall be able to withstand the duty expected of it and the ravages of time for a century, the business man has made a guarantee of the fact on a commercial basis and pocketed his fee.

A fair statement of fact would be something like this:—

First:—The Engineer, beginning with natural aptitude, fostered and encouraged by years of training, and keeping himself abreast the times only by constant study, research and experiment, is today very generally without proprietary business interests, being a man under salary, engaged from year to year.

Secondly:—The very nature of his work unfits him for competition in money-getting, because he studies *things*, while the avowed business man studies *men*.

With this statement before us we are forced to conclude that the Engineer, if he desires to amass a competency, must either abandon his profession, as thousands have done already, becoming in time Railway Presidents, Lawyers, Statesmen, Experts in Insurance, Managers or men of Affairs generally, and we might add, with credit and honor to all concerned, or, remaining in the active practice of his profession, he must have a better show of success as a beneficiary in the distribution of wealth.

The alternative of leaving his chosen vocation can but be distasteful to the honest and ambitious member of the profession. He has made his bed, and if not "Soft as downy pillows are," his rest is sweet and wholesome. He notes that Engineers, considered as educated men and good citizens, average very high, while the mediocrity possible of attainment by persistent effort, before reaching the mean of some of the lines mentioned, is remarkable, not to say appalling, and goes far toward making him a fixture where he is. Again, the Engineer is, generally speaking, a religious man, and dealing with the wonderful forces and resources of nature, he realizes to a far greater extent than ordinary mankind, the wisdom and power of the Almighty Creator of the Universe, and sees more or less clearly, the possibilities of advancement in knowledge during the endless cycles of another world, unhampered by the limitations of this life. He believes himself called to be an Engineer just as truly as the Missionary to preach the Gospel, and as he looks about him, he sees the urgent need of mankind for the work of his brain: mines are to be opened, rivers spanned, railways built and oceans crossed that humanity may be improved and lifted up. It is hard to *stay*, with girls to educate and boys to send through college, but it is harder still to *go*, with conscience in the way. And now let us ask the question, which if it be not asked and an honest effort put forth to answer it, the pertinence of this address is reduced to impertinence: Is there a remedy? There seems to be two modes of procedure;

first, exercise the most rigid economy for, say the first twenty years of professional life. It is generally possible in this country for the Engineer to live upon one-half of his income, by means of self denial and careful scanning of cost before purchase. At the end of this period, just at a time when children are getting out of the lower schools and their future is to be considered, and when experience has developed caution, there will be, from the Engineer's standing point, a very large sum of money available for investment in stocks and bonds which are known to be good dividend payers, or in an established business under competent management.

The second thought is: Association with some bright and honest young man who knows nothing of Engineering but inherits a tendency to trade. Take him into equal partnership, for while you furnish the brains, he will market them at three times what you would probably secure. If you make a valuable invention or discovery, let him exploit it; if you inspect a mine which in your opinion is sure to prove a good thing, allow him to trade in that opinion in his own way if it be an honest way. You may be called to lay out an allotment of city or suburban property; if he thinks best to take option on parts, or buy outright, paying small amounts down, allow him to do so, holding him responsible only for the outcome of the years business, not for individual transactions.

The Engineer has exceptional opportunities for investment:—He is the first man on the ground, and instead of being kept down to a mere salary as now, he should share the profits with the railway manipulator and the land boomer.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

WESTERN SOCIETY OF ENGINEERS.

288TH. MEETING, FEBRUARY 3, 1892:—The 288th. meeting of the Society was held at its rooms, 78 La Salle St., Wednesday evening, February 3, 1892, with over 100 members and visitors present. President Cooley took the chair and called the meeting to order at 8:15.

The minutes of the last meeting were approved and the following list of newly elected members presented:—L. D. May, F. C. Williams, Wilson M. Vinyard, Melville Brown, F. A. MacDonald, R. H. Bethel, L. H. Evans, Richard D. Gottlieb, Carlton R. Dart, Vibe C. Spicer, Wilmer W. Salmon, Jas. S. Robinson, Henry M. Sperry, Joseph I. Kelley, Albert W. Smith, John W. Clark, Geo. M. Walker, Samuel M. Rowe, Edwin Duryea, Wm. A. Parker.

The following applications were received for membership: John H. Burnham, Joseph A. Watson. T. J. Nichol resumed membership.

On the call for reports of Standing and Special Committees the Secretary presented a progress report from Mr. Richard P. Morgan, Chairman of the Committee on the Chicago Railway Problem etc., in concluding which he hoped to be able to present the report within sixty days.

Mr. Hiero B. Herr appointed has been to fill the vacancy in the Committee on the Chicago Railway Problem etc., caused by the death of Col. R. B. Mason, and has signified his willingness to act.

The president announced that he would designate as a committee to prepare a suitable memorial on Col. R. B. Mason, the past presidents of the Society, the senior past president to be chairman.

A letter was read from Mr. J. Frank Aldrich, Commissioner of Public Works of Chicago, asking the Society to appoint a committee of say three engineers from among the membership to make a thorough and impartial investigation of the whole subject of the Water Tunnels without fear or favor to any one, and to report the result of that investigation to the public etc.

PRESIDENT COOLEY: This communication is a matter of much importance and requires some deliberation on the part of the Society. Most of you are probably familiar with the circumstances as they have been discussed in the press of the city, and I hope that you will give the question such considera tion and deliberative judgment as the importance of the subject seems to require.

GEN. FITZ SIMONS: After some remarks in opposition to the proposition, offered the following resolution:

Resolved, That the communication from the Commissioner of Public Works of the City of Chicago, be suitably acknowledged by the Secretary, thanking him for the confidence he has in the Society, but also stating that it is outside the province of the objects of this Society to engage in such work. Seconded.

A spirited discussion ensued in which Messrs. Randolph, Onward Bates, Kandeler, Stickney, Chas. V. Weston supported Gen. Fitz Simons' motion and Messrs. Gottlieb, Lundie, E. H. Lee, and Strobel that of the following resolution presented by Mr. O. Chanute.

WHEREAS, The Western Society of Engineers has received a communication from the Honorable Commissioner of Public Works of Chicago asking that the Society designate a Committee of three members who shall investigate and report "concerning the condition of and the progress being made in the construction of our new Water tunnels,"

Resolved, That the Society recognizes its responsibility in a matter of this kind and that it refers the request of the Commissioner to the Board of Directors, for such action as in its judgment it may seem expedient, with the recommendation however, that should the Board conclude to act in the premises, it shall submit the names of ten or more of the Civil Engineers of this country, whether members of this Society or not, who are best fitted to perform the duties required by the Commissioner, leaving him free to make his own selections and arrangements.

Before the motions were put to vote a communication was received from the judges of election, and the regular order of proceedings was interrupted to receive the following:

"We the undersigned judges of election, having performed the duties required of us, report as follows:

For President, whole number of votes, 241.

Necessary for a choice, 122, of which:—Isham Randolph received 133, J. F. Wallace, 94, R. P. Morgan, 14.

(Signed) T. Appleton.
J. C. des Granges,
Fremont Hill.

Mr. Richard P. Morgan having declined to allow his name to be used as a candidate for election to the Presidency of the Society, the votes cast for him were without his sanction and may be considered as evidences of personal regard only.

MR. COOLEY:—I have the pleasure of announcing that Mr. Isham Randolph has been elected President of the Society for the ensuing year, and I will call Mr. Randolph to the chair. In leaving the chair I desire to thank the Society for the cordial support which it has given me during my two terms of office and for the confidence which it has displayed in me under very trying circumstances, and the only thing that I have to remark in connection with the matter is the assurance that in some degree possibly I may have been worthy of that confidence; I hope that I have. Gentlemen, I thank you.

MR. ISHAM RANDOLPH, upon being introduced as the new President of the Society, spoke as follows:

Friends, comrades, men of the Western Society of Engineers,—you will pardon me if your action to-night has filled me with a swelling pride —this is no puny emotion, but a mighty sentiment welling up for utterance. I did not seek this honor, I never turned my hand to gain it: I controlled but one vote and that vote I cast in this election, but not for myself. This great Society of ours has forged to the front and stands before the people of these United States as a power in our land. Last spring

I was with a committee of this Society who went to see what the East had done and were doing to mitigate and remove the evils of grade crossings, and learn what advance in the arts of construction had been made which we of the West knew not of. In the very start I, comparatively unknown, wrote to the management of the Chicago & Grand Trunk Railway, asking for transportation of our commission. Had this request come from me as an individual, it would have found speedy issue in the waste basket, but coming as it did, with the sanction of your commission. the response was prompt and courteous, and the tender of further civilities was most courteous. All through that trip we who made it had every opportunity of seeing the high esteem in which this organization of ours is held by men of high authority and of commanding influence. But to come nearer home. A little more than a year ago the retiring President of this Society was summarily removed from high position of trust, because he had the backbone to antagonize a faction in power, which, after removing, pursued him with the vindictive purpose of humbling the man who had had the termerity to attempt to thwart its plans. This Society, by a majority of its voters, avowed its faith in Mr. Cooley's integrity, ability and courage, and placed him at its head. Such action by such men stemmed the tide of public opinion and made honest, thoughtful men ask questions and seek to know the truth. The rest is history so modern that the shortest memory grasps it still.

With all this before me, is it any wonder that I am proud to occupy the chief seat in your synagogue, even for a few brief months? I am putting my armor on and going all untried to the battle, a battle which I can never win without the earnest support of every man whose name is upon our muster roll. This support I am entitled to, and I demand it of each and every one of you, whether you voted for me or against me. You must be loyal, not to Isham Randolph, but to the Society for which he stands. Only by loyalty to your chief can you secure the advancement, the dignity and honor of this profession. Friends, I count you all as friends whose names are upon our rolls, I thank you, and I pledge myself to serve you to the best of my poor ability.

Upon request of Gen. Fitz Simons the two motions in connection with letter of the Commissioner of Public Works of Chicago were again read.

The discussion was resumed with Mr. Cooley speaking for Mr. Chanute's motion while Gen. Fitz Simons' and Mr. G. W. S. Ferris opposed it.

A vote was then taken on the question of substituting Mr. Chanute's motion for that of Gen. Fitz Simons' resulting in the substitution by a vote of 51 to 28.

A similiar vote was recorded on the adoption of Mr. Chanute's motion.

A letter was read from Mr. T. W. Parvin, member of the Society, offering to describe an immense smelting works in Mexico, of which he was chief engineer of construction, at the March meeting.

The Secretary was instructed to reply, stating the Society would be glad to hear from him.

A written discussion of the Report on Bridge Legislation was read by Mr. Horace E. Horton in defense of highway bridge builders, which attracted considerable attention.

Owing to the lack of time the reading of the paper by Mr. Gottlieb on the "Behavior of Iron Columns under High Temperatures," was postponed and the meeting adjourned.

John W. Weston, Secretary.

THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

FEBRUARY 9TH, 1892:—Club met at 8 o' clock P. M. with President Gobeille in the chair and 27 members and 3 visitors present. The minutes of the last meeting were read and approved. The Executive Board recommended the election of Messrs. Sidney R. Badgley and Peter Neff Jr. as Active Members and Mr. Edwin L. Thurston as Associate Member.

Mr. Wm. T. Blunt read extracts from circular No. 2 of The Executive Committee of the General Committee of Engineering Societies Columbian Exposition giving the plan of the work as far as at present laid out. Mr. Barber moved "that this Club approve and ratify the action of the Executive Committee as far as they have gone as described in circular No. 2." The motion was seconded and some discussion followed after which the motion was put and carried.

The report of the committee on nomination of candidates for officers for the ensuing year was read.

The Candidates were:

For President: Cady Staley, Walter P. Rice.
For Vice President: A. H. Porter, F. A. Coburn.
For Secretary: C. S. Howe, C. M. Barber.
For Treasurer: C. P. Leland, J. L. Cully.
For Librarian: E. P. Roberts, C. H. Benjamin.
For 1st. Director: J. D. Varney, C. H. Strong.
For 2nd. Director: Walter Miller, G. A. Hyde.

Prof. Howe withdrew the name of Dr. Staley, stating that his time would be so fully taken up during the coming year that it would be impossible for him to accept the office if elected. Motion was made and seconded that the report of the committee be accepted. Prof. Howe moved an amendment that Dr. Staley's name be stricken from the list and that the committee be instructed to fill the vacancy. This amendment was seconded, voted upon and carried.

Mr. Barber made a report of the reunion of the alumni of the Rensselaer Polytechnic Institute recently held in this city.

On motion by Prof. Howe the chair was instructed to appoint a banquet committee of 7 members with power to select the date and place, and make all necessary arrangements for the annual banquet.

The chair stated that the committee would be announced later in the evening. Mr. John L. Cully then read the paper of the evening entitled; "Mining Engineering."

He gave an interesting account of the work to be done in making surveys of mines from the time the engineer arrives on the ground till the last course is finished, and the manner in which this work should be done. The difficulties encountered and the methods of overcoming them were fully described, also the checks that are used in proving the accuracy of the survey and the methods of locating the required lines on the surface.

The paper was discussed by a number of members and several ingenious methods were described for overcoming many of the difficulties encountered during the execution of this kind of work.

The chair announced the following banquet committee: C. P. Leland, Chairman, C. S. Howe, W. R. Warner, C. M. Barber, E. P. Roberts, C. W. Wason, W. L. Otis.

On motion adjourned. A. H. PORTER, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

361ST MEETING, MARCH 2, 1892:—The club met at 8 p. m. at the club rooms, President Johnson in the chair and twenty-three members and two visitors present. The minutes of the 360th meeting were read and approved. The Executive Committee reported the doings of its 126th meeting.

Messrs. A. S. Cushman, A. H. Baldwin and Morris Wuerpel were elected members of the club.

Chancellor W. S. Chaplin was proposed for membership.

The secretary read a communication from Mr. O. Chanute, inviting the members of the club to attend and take part in the International Congress for Internal Navigation, at Paris, France, in July.

Mr. J. A. Laird described the character of the cast iron used in the Worthington engines at the St. Louis water works. The specifications and tests applied were described and specimens exhibited.

Discussion followed by Messrs. Ferguson, Blaisdell, Seddon, Johnson, Crosby, Laird, Thacher, Gaylor and Hermann.

Adjourned. ARTHUR THACHER, Secretary.

362D MEETING, MARCH 16, 1892:—The club met at 8 p. m. at the club rooms, President Johnson in the chair and sixteen members and two visitors present. The minutes of the 361st meeting were read and approved. The Executive Committee reported the doings of its 127th meeting.

Chancellor W. S. Chaplin was elected a member of the club.

Messrs. A. A. Stuart, C. B. White and T. L. Condron were proposed for membership.

Prof. Potter announced that the Citizens' Committee on the "Prevention of Smoke" would make a report on Friday evening, to which the members of the club were invited.

Mr. Arthur Winslow then presented the paper of the evening on "The Progress of Mapping in Missouri." The paper sketched the history of map making and showed its connection with the advance of civilization. The early attempts at maps of North America were described and copies of these maps were exhibited. The early maps were extremely curious, and the series showed not only the increasing knowledge of the country, but also the greater ability of the surveyors. In more recent times the work was begun by the United States Coast Survey in 1871 with a triangulation across the State. In 1882 precise leveling was carried across the State. The Mississippi River Commission had carried the work on along the river. The Missouri River Commission had followed the Missouri River. The United States Geological Survey, from 1884 to 1889, mapped about one-third of the State in the central part. The State Geological Survey is at present engaged in mapping the State chiefly for geological purposes. Specimen sheets were exhibited, showing the nature and character of the work. Through the courtesy of Capt. Palfrey some of the original atlases were shown to the club.

Discussion followed by Messrs. Johnson, Moore, Winslow, Ayer, Potter and Capt. Palfrey.

A vote of thanks was given to Mr. Winslow and Capt. Palfrey.

For the meeting of April 6th a paper by Mr. E. A. Hermann on "Steam Shovels and Steam Shovel Work" was announced.

Adjourned. ARTHUR THACHER, Secretary.

CIVIL ENGINEERS' SOCIETY OF ST. PAUL.

APRIL 4, 1892:—Regular monthly meeting held at 8:15 P. M. President Woodman in the chair and thirteen members in attendance. The librarian was empowered to purchase a hat rack and a wash basket. Mr. R. Davenport read a paper on the Red River of the North. This river is a ditch in the prairie meandering on an average two miles to make one, with a discharge varying from 250 to 20,000 cu. ft. per second at Breckenridge and from 600 to 50,000 at Pembina.

In 1877 was begun the first work of improvement, estimated to cost about $300,000 and intended to render the river navigable during a part of the year for flat bottomed craft, by dredging and the removal of bank obstacles from Breckenridge to the Canada line, a distance of about two hundred miles. $240,000 have already been expended. The banks are subject to slides peculiar to the river; large volumes of earth having a tendency to work themselves into the river at the level of its bed in the form of wedges extending horizontally well back from the river. The movement of these masses leaves the surface of the bank above to settle undisturbed. The traffic on the river wholly local seems to have varied with the precipitation. From 1879 to 1882 it increased from 18,000 tons to 32,000 tons, then decreased to 1700 tons in 1890. Last season it grew to 12,000 tons.

It is estimated by Major Jones, U. S. Engineer Corps that a further expenditure of $300,000 in reservoirs would make the river navigable the year round excepting in the frozen season. With $550,000 more in locks, dams and canals the length of navigable tributaries might be doubled.

C. L. ANNAN, Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.
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ON THE POSITION OF THE CENTER OF ALL THE DRY LAND ON THE SURFACE OF THE EARTH.

BY JOHN N. STOCKWELL, MEMBER OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read January 12, 1892.]

The motive which prompted the preparation of the following paper would not be apparent from the paper itself; and I have thought it eminently proper to give a brief introductory account of the succession of events in the history of mankind, which has rendered such an investigation either desirable or useful.

In the early ages of the world, mankind were few in number, and being settled in the same locality, they all possessed similar wants and spoke the same language. But in process of time the affair at Babel took place, and the subsequent dispersion of mankind over the face of the earth obliged the different tribes to grow up under dissimilar physical conditions, which produced different race developments and different wants.

But the fundamental wants of mankind are essentially the same the world over; and people of the same race, while living under different physical conditions would resort to different methods to satisfy their common desires. Among the numerous desires of a people advancing in civilization, would be found methods of measuring time, and for fixing the metes and bounds of estates and territories, units of length would be required. And hence we find that the ancient Persians denoted the date of events by reference to the year of the reigning sovereign when it occurred; and the Greeks recorded events by referring them to the year of the particular Olympiad when they took

place. For the measure of long distances the Persians employed a measure called a *parasang*; while the Greeks used a measure called a *stadium* for the same purpose. For shorter distances a unit of measure called a cubit was employed. The early Romans dated events by referring them to the year of the foundation of their imperial City; and gave long distances in terms of the *mile*, which was somewhat shorter than the English statute mile.

It is evident that the date of any event could be referred to either of the three systems, Persian, Grecian, or Roman, when the fundamental relations between the systems had once been established. But it is evident at a glance that the merits of the systems of chronology adopted by the three nations mentioned, were altogether different. The Persians referred events to the year of the reigning king; and as these reigns were of unequal and uncertain length, it was often a matter of some difficulty to determine the dates of their occurrence; but the Greek system was not much better, although somewhat more scientific in its general nature, because they designated the Olympiads by the names of the victors in the games rather than by their number counted consecutively from the first. The Romans, however, by counting the years consecutively from the founding of the City of Rome, employed a method of dating events, far superior to those in use by the Persians and Grecians.

In process of time, however, when the course of events had brought the commercial nations of the world into contact with each other, a comparison of the methods employed by the different nations would very naturally suggest some modifications and changes in practice. In the early ages the lapse of time was very generally measured by means of the motions of the moon; but as the year is not composed of an even number of complete lunations, it was long a matter of some difficulty to find a period of time which was an exact measure of both. This was however accomplished by Meton, a celebrated astronomer of Greece, about the year 433 B. C., who found that two hundred and thirty-five lunations were equal to nineteen tropical years. This discovery was regarded so important that the Athenians had it inscribed in letters of gold upon the walls of the temple of Minerva; and hence the term *Golden Number*, which denotes the year of the lunar cycle.

The Roman calender, during the republic, was made up of months which were measured by the moon, and of years which were measured by the sun; and as there was no common measure of these two quantities, the calendar often fell into confusion; and so great was the inconvenience arising from this source, that Julius Cæsar when he became dictator, reformed the Roman calendar by abolishing the use of the moon as a measurer of time, and regulated the years wholly by the motions of the sun.

The Roman calendar thus formed by Julius Cæsar continues in use, or rather forms the basis of the calendars in use in Europe and America at the present day. It consists in giving the common years three hundred and sixty-five days, and making each fourth year contain three hundred and sixty-six days; so that the true length of the civil year would be three hundred and sixty-five and one-fourth days.

In the same way, weights and measures underwent modifications and changes: but in process of time the work of reformation began. The Julian calendar was a real improvement of the old Roman calendar; but since his civil year was 365¼ days, while the tropical year was 11m. 12s.74 shorter, it is evident that the sun would reach the equinox about eleven minutes before the end of the civil year. And since this would be repeated each year, it would amount to a whole day at the end of about 128 years. At the time of the reformation of the calendar by Julius Cæsar, the vernal equinox fell on the 23rd of March: but at the time of the ecclesiastical council of Nicea in A. D. 325, it fell on March 21: and the assembly of Christian bishops then decreed that the festival of Easter should always be the first Sunday *after* the full moon which happened upon or next after the 21st of March. Now in order that Easter might always happen at the proper time of the year it was necessary to so modify the Julian calendar that the equinox should always occur about the 21st of March; but this was not done till the year 1582, when Pope Gregory XIII published a bull, cutting off ten days from the year 1582, and commanding to reckon the 5th day of October as the 15th. And in order that the equinox might always occur about the same time of the year it was further decreed that three bissextile years should be omitted every four hundred years.

It was for the frivolous reason of making Easter come at the right time, that the beautiful simplicity of the Julian mode of reckoning time was abolished, and one less simple substituted in its place. It was adopted by the Catholic countries of Europe according to the Pope's decree; but it was not adopted in England till the year 1752, when their 3rd of September was reckoned as the 14th,—the Julian calendar then being erroneous by eleven days. At present, none follow the Julian calendar in Europe, but the Russians and the Christians of the Greek church, whose year begins twelve days later than ours.

The introduction of the Gregorian calendar met with much popular opposition; and it must be conceded that in this case the common sense of the people was more nearly correct than the wisdom of the learned. It is one of those singular cases which sometimes arise in which reformation is not improvement. I have thus dwelt with considerable detail on this question of the calendar, because it is one of popular interest, and also one of the most important that has ever occupied the at-

tention of mankind; and I shall now hurry more rapidly through the remainder of these introductory remarks.

It is now one hundred years since the civilized world was convulsed from center to circumference by the Great French Revolution. That great upheavel liberated the people of France from the most grinding despotism; and they passed at once from the condition of abject slavery to that of entire freedom. This sudden change in their political condition gave birth to unwarranted license, and they at once became a nation of iconoclasts, overturning by legislative enactments, the habits and customs which had prevailed in their country for centuries. Nothing was considered as venerable or sacred in their estimation. They became at once a great nation of *reformers*. They reformed everything; and it is owing to questions arising from this universal reformation, that has given rise to this discussion. They became possessed of a mania for decimals. Instruments for measuring time or space were to be made with special reference to a decimal division. The day was to consist of ten hours, and the week of ten days. The hour was to consist of one hundred minutes, and the minute of one hundred seconds. The quadrant of the circle was to be divided into one hundred degrees, each degree into one hundred minutes, and each minute into one hundred seconds. For linear measurements the meter was to be the unit, and its subdivisions were to be decimal. The length of the meter can only exist as a theoretical abstraction. It has never been constructed; nor is it practicable to construct one. It is defined to be *one ten-millionth* part of the quadrant of the meridian passing through Paris. The use of all former unitsof measurement was formally abolished.

Such are a few of the reforms introduced by the French Republic about a century ago. They may be well adapted to the wants of the people of France, but they ought not to be adopted by other nations until assured that they are better than those now in use.

But all nations have reformers and these reformers are usually either pessimists or optimists. To the former, every change must be for the better; while to the latter every change would be for the worse. Now we have in this country what is called the American Metrological Society, and the great aim of that Society seems to be to induce Congress to authorize the adoption of the French Metric System of weights and measures in this country. This Metric Society, as it might be called, has given rise to another, which takes the name of Anti-Metric Society, the object of which is to discourage legislation favorable to the French System.

Before proceeding further it may be well to inquire into the relative merits of the English and French systems of linear measure. By definition the *meter* is the ten millionth part of the quadrant of the

meridian; and its approximate length is 39.37 English inches, or 3.2809 feet. In order to carry such a measure conveniently in ones pocket, it would be necessary to fold it about twelve times. It would then a little exceed the length of the foot rule when folded four times. So many joints, however, in such a measure would render it inconvenient for use, and it would certainly possess no advantage over the English foot measure. But one great advantage claimed for the *meter* consists in its decimal division. If that were any advantage, the foot rule might also be decimally divided: which would abolish the denomination of *inch* as an English unit of linear measure. But I do not conceive that the decimal division of a scale possesses any advantages over a scale divided into either twelve or sixteen parts, or even of their multiples. It is certainly easier to divide a number by twelve than it is to multiply the same number by its decimal reciprocal, and it would also be vastly easier to multiply a given number by twelve than it would be to divide by its decimal reciprocal. And the same may be said with regard to most numbers in ordinary use. So it seems to me that the advantage of decimal division exists more in fancy than in fact.

I do not purpose to further discuss the relative merits of the two systems of measures; but there is one consideration that ought not to be lost sight of in this connection, and that is the expense necessary to replace our present system of measures by any different system. Unless the proposed system possessed decided advantages over the present system, it would be an absolute waste of many millions of dollars to fully and fairly introduce the change.

But the discussions of the subject have given rise to the Anti-Metric Society, and this Society has advanced many arguments in favor of the advantages of the English over the French system. Some of these arguments seem to be good, while others are far from convincing. The antiquity of our system is regarded as a strong point in its favor, and certainly a system that has stood the test of time ought not to be ashamed of its antecedents.

I cannot but regard the primary object of the Anti-Metric Society with favor. And so long as they confined their arguments to the real merits of the two systems, I think the advantage was on their side. But in some manner, I hardly know how, another subject of interest came to be associated with it. I refer of course to the investigations concerning the Great Pyramid of Egypt, which have, during the past few years been a subject of discussion throughout the scientific world.

It is claimed by pyramid students that the Great Pyramid was constructed by measures essentially identical with our present English system; and if that claim is correct, it certainly gives a hoary antiquity to our system of measures. And this identity might well be used as an argument in favor of its continued use.

But it is also claimed that the pyramid itself was planned and constructed under the special guidance of Divine inspiration. I can hardly indorse such a claim, as I am not willing to believe that the Creator would identify himself with a work that could easily be accomplished by mere human agencies. However, these are mere opinions, and are not advanced as arguments. Pyramid students also claim that it is so located as to possess important advantages over all other points of the earth's surface. Now when claims of a physical nature are so specific that they can be tested by scientific methods, it is easy to decide whether they belong to the domain of fact or of fancy.

One of the claims of a physical nature concerning the location of the Great Pyramid, is, that it is situated in the center of all the dry land on the earth's surface, and this claim has led to the inquiry as to the position of that center, which is given as the title of this paper.

I may also remark in this connection that we have societies for the unification of weights and measures societies for the unification of time and longitude, as well as societies for the removal of other real or fancied grievances. The objects of all these societies may be good and benevolent; but so long as different nations will persist in speaking different languages I can see no good reason why they should not continue the use of different systems of weights and measures, different prime meridians and different measures of time, if they choose to do so. The measure of my philanthropy does not reach so far as to encourage change in the habits and usages of nations unless they are accompanied by positive advantages.

It is now nearly thirty years since a great impetus was given to the study of the history and object of the construction of the Great Pyramid of Egypt, by the publication of a work by Mr. John Taylor, entitled "The Great Pyramid: why was it built? and who built it?" In that work the author advocates the startling theory that the Great Pyramid was planned and constructed under the direct influence of Divine Inspiration; and that the most profound principles and truths of mathematical and astronomical science are also embodied in its construction. Later Pyramid students not only indorse the theory advocated by Mr. Taylor, but also claimed that all knowledge that can be useful to man, both historical and scientific, embracing all time, both past and future, are in some way ineffaceably impressed upon its walls.

It is not the object of this essay to call in question any of these claims of the students of the Great Pyramid, but there are some other claims, especially in regard to its location and relation to the external world that stand out in bolder outline and are susceptible of more direct investigation, and which can be so presented to the mind of the inquirer as to leave no uncertainty as to the correctness of his conclusions, that I desire to call special attention at this time. Nor do I wish

to discuss any pyramid problems except in a spirit of friendly criticism, believing that the cause of truth will be advanced by relieving the theory of whatever views are merely fanciful and extravagant. I shall therefore restrict this discussion to the three following propositions:—

First. The parallel of latitude on which the Great Pyramid stands has a greater extent of land than any other parallel of latitude on the face of the earth.

Second. The meridian passing through the Great Pyramid has more land than any other meridian; and

Third. The Great Pyramid is at the center of all the dry land on the earth's surface.

In regard to these propositions Prof. Piazzi Smyth says:—"For proceeding along the globe due north and due south of the Great Pyramid, it has been found by a good physical geographer as well as engineer, Mr. William Petrie, that there is more earth and less sea in that meridian than in any other meridian all the equator around. Hence, therefore, the Great Pyramid's meridian is caused to be as essentially marked by nature, in a general manner, across the world from Pole to Pole, or rather from the North Cape of Norway to the diamond fields and Zululand of South Africa, as a prime meridian for all nations measuring their longitude from, or for that modern cynosure 'the unification of longitude,'—as it is more minutely marked by art and defined by human work within the Lower Egyptian plain, by the pointed building itself alone."

"Again, taking the distribution of land and sea in the parallels of latitude, there is more land-surface in the Great Pyramid's general parallel of 30°, than in other degree; so that the two grand, solid, man-inhabited earth-lines, the one, of most land in any Meridian and the other of most land in any Latitude, cross on the Great Pyramid. And finally, on carefully summing up the areas of all the dry land habitable by man all the wide world over, the center of the whole falls within the Great Pyramid's special territory of Lower Egypt." (*Our Inheritance in the Great Pyramid. p. 89*).

Again, W. J. Cockburn Muir, of Melrose, Scotland, says, "The fact that the Pyramid is at the center of all the Dry Land is one of a category, the other two of which reinforce and accentuate its immense significance. On the meridian through that center is the greatest length of Dry Land in Longitude (*latitude?*), and on the latitude of that center is the greatest length of Dry Land in latitude (*longitude?*)." (*International Standard, Sept. 1887, p. 258*).

Now in regard to the first of these propositions I find that the land of the thirtieth degree of north latitude extends through an arc of 165° of longitude, while the land of the fiftieth degree of north latitude, extends through an arc of 222° of longitude. If we multiply these num-

bers by the cosines of their respective latitudes we find that the arc of parallel through the Great Pyramid is equivalent to 142°.9 of a great circle, while that of the 50° parallel amounts to 142°.7, so that there seems to be a slight preponderance in favor of the Pyramid's parallel. The first proposition is therefore correct.

In regard to the second proposition, I find that the meridian of the Great Pyramid contains 92° of land in Europe, Asia, and Africa, and 10° in North America, making 102° in all: while the meridian of 70° west from Greenwich contains 94° of land in the Americas and 55° in Asia, making 149° in all. There is therefore nearly fifty per cent. more land in the meridian of 70° west, and 110° east longitude than there is in the meridian of the Great Pyramid. The second proposition is therefore not true.

In order to investigate the third proposition it is necessary to explain what is meant by the term *center* of land when applied to an irregular system composed of land and water. I shall define it as that point of the system which has more land and less sea within a given distance, measured on the surface of the earth, than any other point of the system.

For example, take the British Islands, containing the whole of England, Scotland and Ireland. A circle having a radius of about 330 miles, and with its center in the Isle of Man, would contain more land and less sea than any other circle having the same radius. The Isle of Man is therefore the center of the system of British Islands.

Let us now enlarge the circle of our investigation, and seek for the center of the land comprised in the three grand divisions of the globe called Europe, Asia and Africa. Let us first make trial of the Great Pyramid as a center and see if a circle with that point as a pole, and including the whole of the land specified, will also contain less sea than any other point as a center. The distance of the Great Pyramid from the Cape of Good Hope, at the southern extremity of Africa is about 4400 miles, while the distance to East Cape at the farther extremity of Asia cannot be less than 5800 miles. If we leave out of consideration about 500 miles of the peninsula of Kamtchatka, which cannot much affect the result, the radius of the circle having the Pyramid as a center which would include substantially the whole of Asia, would be 5300 miles. This circle would therefore extend about 900 miles to the southward of the Cape of Good Hope, and embrace a vast tract of ocean extending from the Island of Java through the whole extent of the Indian and Atlantic oceans and extending beyond the North Pole before it reached the Northern Asiatic coast. On the other hand a circle having a radius of only 4400 miles, and just including the whole of Africa would leave a portion of Asia many thousands of miles in length and nearly a thousand miles in breadth, entirely outside. It is there-

fore evident that the Great Pyramid cannot be very near the center of the three great eastern continents.

Let us now see if the city of Damascus is nearer the center than the Great Pyramid. Damascus is north-east of the Great Pyramid and distant from it by about 400 miles. It is therefore about 4800 miles distant from the Cape of Good Hope, and a circle of 4800 miles radius and center at the city of Damascus would include the whole of Africa and Europe and very nearly the whole of Asia, with the exception of the peninsula of Kamtchatka, already mentioned. It is therefore evident that the City of Damascus, which may well be called the Eternal City, being the oldest city in the world, is very near the center of the three great continents of the eastern hemisphere.

If we now still further enlarge our circle of comparison so as to include the whole of a hemisphere, we shall find that if the pole of the hemisphere is at the Great Pyramid, the land included in its great circle would embrace the whole of the continents of Europe, Asia and Africa, together with about one-half of North America and one-third of South America, omitting all notice of the numerous islands that are also included. All the lands here mentioned are situated within a distance of one-quarter of the circumference of the earth, or 6218 miles of the Great Pyramid.

In Black's Atlas of the World, the pole of the hemisphere containing the greatest amount of land is placed very near the City of London: and the whole of Europe, Asia, Africa and North America together with three-quarters of South America are included within its great circle. It is therefore evident that the hemisphere of which London is the pole contains several millions of square miles of land surface more than the hemisphere whose pole is at the Great Pyramid.

But if the pole in 10° west longitude from London, and in latitude 52°, which would place it in the vicinity of Valencia, its great circle would leave out about 142,000 square miles of land surface across the peninsula of Siam in the east, which would be included within the great circle whose pole was at London; but it would embrace a belt of land nearly 300 miles wide and 2000 miles long, across the South American continent, including an area of nearly 600,000 square miles which was outside the former great circle. Thus the great circle whose pole is near Valencia would include 458,000 square miles of land surface more than the great circle whose pole is at London; and it is not easy to find a great circle which will contain a greater amount of land on one side of it.

We shall now extend our circle so as to include the whole of South America and Australia. Our circle will then include all the dry land on the face of the globe with the exception of New Zealand and the multitude of nameless small islands of the central Pacific Ocean. It is

evident by the inspection of a terrestrial globe, that the small circle which passes through Cape Byron on the east coast of Australia, Cambridge Island on the west coast of Patagonia, and Cape St. Lucas, at the southern limit of Lower California, will leave all the required land on one side of it: and we must now determine the position of the pole of this small circle.

For this purpose we shall assume, in accordance with the maps of the best geographers that the latitudes and longitudes of these places are as follows:—

	Lat.	Long.
Cape St. Lucas	N. 22° 54′	W. 109° 36′
Cambridge Island	S. 50° 10′	W. 75° 10′
Cape Byron	S. 28° 36′	W. 206° 20′

Now the longitude of the Great Pyrmid is E. 31° 10′, and its latitude is 30° north. Supposing the earth to be a sphere with a radius of 3958.3 miles, we shall easily find

Distance of Pyramid from Cape Byron is 9008 miles.
Distance of Pyramid from Cambridge Island is 8475 miles.
Distance of Pyramid from Cape St. Lucas is 8564 miles.

The Pyramid being unequally distant from these places cannot be the pole of the small circle passing through them. The direct solution of the problem of finding the position of the pole of the small circle which passes through the above places is very readily obtained; but it may also be easily solved by a series of successive approximations. And we have found the position of the pole to be in lat. 24° 27′ N. and longitude 37° 52′ east. The distance of this point from each of the three given places is 8504 miles; and its location is in Arabia about 120 miles to the westward of the City of Medina, near the eastern coast of the Red Sea. The center of all the dry land is therefore near the City of Medina, five hundred and sixty miles due south-east of the Great Pyramid.

It is perhaps unnecessary to further extend this investigation: but I may incidentally remark that the effect of including the Islands of New Zealand within our circle, would be to carry the center of the whole to the eastern part of Arabia, a distance of about 1800 miles from the Great Pyramid. I am therefore unable to agree with the Pyramid students in their claim that the Great Pyramid is situated in the center of the land surface of the globe.

The preceding investigation was undertaken at the special request of the late Mr. Charles Latimer, and was nearly completed at the time of his death. It was his earnest desire to know the *truth* in all things, regardless of its effect on the speculations of men and the theories it might establish or overthrow. J. N. S.

DISCUSSION.

MR. WARNER:—I would like to ask if it was not a fact that the workingmen thought they were cheated out of ten days pay?

MR. STOCKWELL:—That would be raised as an objection against making this change in the calendar. The change was made in our present calendar in all Catholic Countries by edict of Pope Gregory 13th, in 1582, but this calendar was not adopted in England until 1752 when, by act of Parliament, the 3rd day of Sept. was called the 14th, thus moving the calendar forward eleven days.

MR. RITCHIE:—Was it not a fact that they had lost that much time?

MR. STOCKWELL:—In reality any change in the calendar would not affect the wages or pay of anyone.

MR. BROWN:—Could not this Center be found by taking the land as laid down on a sphere, develope this surface, then suspend it by some point and note direction of the vertical line through the point of suspension; then suspend it by another point and note the direction of another vertical line passing through the point of suspension. The intersection of these lines would give the Center of Gravity.

MR. HERMANN:—Could not the Center be found by coating the surface of a globe with tinfoil, then scrape off that part which covers the water and the part left on would represent the land. Then immerse this globe in water and the part coated with tinfoil would settle to the bottom and the lowest point would be the Center of Gravity.

MR. STOCKWELL:—Either of these methods would determine the Center of Gravity of all the dry land, but the Center of Gravity is not the point that is wanted.

MR. BARBER:—I would like to ask Mr. Brown how he would develope a sphere. All our text books state that the surface of a sphere cannot be developed.

PROF. MORLEY:—Whole volumes have been written on these Pyramids. Prof. Piazzi Smyth has written two volumes and I read them through thoroughly for the purpose of finding the point that he was trying to establish and I must say that I am still unable to see any point in them. He made three measurements for the purpose of establishing the unit of which the side of the Pyramid is a multiple. He assumed three numbers and took the average. The numbers were to each other as 50-100-150.

QUESTION:—What particular object would there be in having the Pyramids located at the Center?

PROF. MORLEY:—No particular object only that it is the opinion of some that this point was selected by some power greater than human and that it was selected because at this point the temperature is more nearly constant than at any other place.

QUESTION:—I would like to ask your opinion of the one great object of the Pyramids. Were they built simply to be the tombs of Egyptian Kings, or have they another value?

PROF. MORLEY:—I can not answer that question at all. I cannot see any other reason for their construction. I would like to give you a little idea of how accurately these measurements were made. Prof. Piazzi Symth stood at one corner of the Pyramid and had an Egyptian with a staff at another corner. The plumbing was done by the eye without any other instruments than this plumb line, and Prof. Smyth from the corner at which he stood decided that the Pyramids were exactly North and South.

PROF. HOWE:—I have not been so interested in a discussion since I graduated fourteen years ago. I had "The Pyramids" as the subject of my oration. I settled the question then, but which way I cannot tell now.

MINING ENGINEERING.

BY JOHN L. CULLEY, MEMBER, THE CIVIL ENGINEERS CLUB OF CLEVELAND.

[Read Febuary 9, 1892.]

However limited your education or experience, the average individual, if he has confidence in you, thinks you can do anything in engineering. This was quite the case in 1881 when I was called upon to locate a slope entrance to an inside coal mine entry. The inside workings were reached through a shaft 41 feet deep and through several entries whose courses made as many right angles. I had never been in a mine before and I may add I never was more scared by the magnitude of an undertaking. The happy condition of seeing everything in surface work suddenly departed into the dense darkness that enveloped every thing. It was impossible to find a light 100 feet away, and when at last it was found you were not sure that the cross hair was not some string or other object dangling down from the roof. The instrument began to perspire and so did I! Nor did I know whether I was afoot or horseback when the survey was complete, tho' the mine-boss was kind enough to assure me that I was not far from right, which afterwards proved to be correct.

The conditions of inside and outside instrument work are quite different, and it will take some time to overcome the obstacles to inside work. The chances are that the first time you ever attempted, in surface work to find an object near at hand you missed it and did not find it without quite an effort. Now you will at once sight an object 2000 feet away. It is the same in mine work intensified, for everything be-

ing in Egyptian darkness, you cannot range along familiar objects until the one sought is found.

The following incident will illustrate the difficulties sometimes encountered in inside instrument work. In a recent mine survey extension, the instrument was set up ready for the first sight, but when the engineer tried to find the light he utterly failed to do so, tho' pursuant to his instructions it was raised and lowered carried to the right and then to the left. His assistant then tried his hand with no better result. At last one of the miners discovered that the object glass cap was on!

With a little experience you handle your instrument with certainty and precision, take in the alignment, note your surroundings and will be at home with your work.

There are certain precautions to be observed, if you wish all to go well and these can be best stated by a description of a working party. Besides the engineer, the party should consist of a pilot or foresight, who goes ahead and selects the transit or angle points, two chainmen, a torch bearer to the instrument and a back sight, or six men all told, each provided with a miners lamp, and all with oil enough to maintain the lights until the party returns to the surface. The pilot should be thoroughly familiar with all the mine workings and be able to select instrument points of vantage, that their number shall be the fewest possible or the courses the longest. The superintendent or mine boss is generally selected for this position. The hind chainman should be an experienced one, for upon him depends the accuracy of the measurement. You should therefore supply this man yourself. The torch bearer first lights the plumb bob next the upper plate until it is level, then the vernier, then flashes the cross hairs, and finally the vernier reading. In setting or reading the vernier, stand square to the vernier with the left hand on the upper plate, and cause the torch bearer to pass his light over your left hand to a point slightly above and to the right of the center of the vernier. You will then be able to read it without trouble. The setting of the plates will be greatly facilitated if a small rosette be put on the outside of the lower plate directly under the 0.0 of the horizontal limb. Then to set the plate at 0.0 pass your hand around the plate until the rosette is met and then bring it and the vernier at once together. Otherwise frequently several revolutions are made before the desired position is obtained. The flashing of the cross hairs is a very simple operation when properly done. Put the instrument in position, find the light and nail in front of it, then direct the torch bearer to "flash" and he will pass the flame of his light directly across the telescope axis 2″ in front of the object glass, until the cross hairs are in position. The position of the sight nail is more clearly defined if an ordinary surveyors marking pin is held

plumb over or in front of it. The sight lamp, nail and telescope should always be in a straight line. The angle having been obtained you notify the chainmen to measure up to your position, you proceed to the foresight, the back sight takes your position, and the foresight seeks a new point. In this way the entire mine is surveyed. The end of the last three courses of each entry are permanently located in the roof or top of the entry, by drilling a hole in it, into which a wooden plug is tightly driven, and a nail into the plug to indicate the exact instrument point. The future extension of the survey begins at these points.

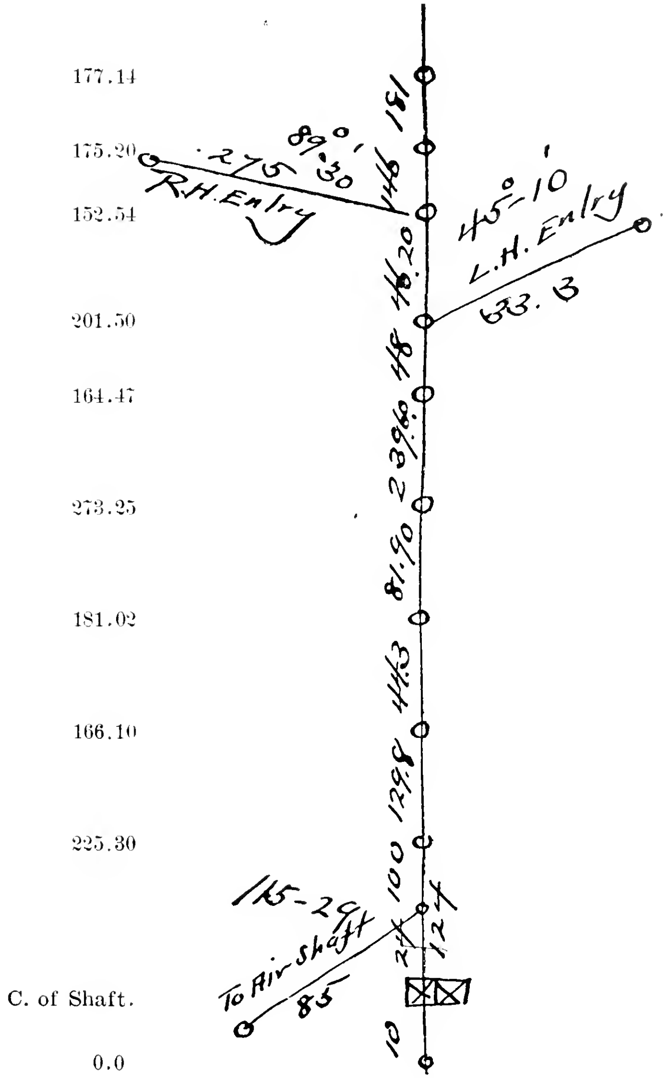
Ten years ago it was the universal practice to read and note all the angles as right and left—a most pernicious and deceiving practice. Thus you observe 18° 32′R and just as you set down the figures the chairman announces the lengths of the last course, or other information is given you to note. The next day you discover to your horror that the 18° 32′ you so carefully put down is without the characteristic R or L. The same is true with R. & L. field book columns, you are liable to note the angle in the wrong column. The only true way to observe and record angles is to turn them all to the right from zero, and record them just as they are observed, though they be as large as 359° 59′. We are glad to state that this latter system is now quite universally used,—no small convenience when a disputed territory is to be jointly surveyed by engineers representing the opposing interests.

Careful test needle bearings have been made of courses in and out of mine. Their variations are irreconcilable. Often the same course will vary 10°. Yet there are those who attempt to make mine surveys by the needle, and are surprised at the great departure of other engineers from their findings.

March 10, 1888, I wrote an article in the *Engineering News* that undoubtedly had something to do with the general adoption of right hand angle reading. A line was drawn through the center of the field book and the notation was read from top to bottom of page. It only remains to reverse this order and read from bottom to top, like a R. R. transit book, to render the notation perfect. Then all lines from the main line could be graphically noted R. or L. just as they occur, thus:— (see opposite page.)

On account of the grease and dirt encountered, it is advisable to take the mine notes in a memorandum book, and the next day review and copy them into a regular field book.

All mine entries in this section are more or less crooked and full of innumerable angles. In dealing with this quantity of lines and angles both inside and outside of the mine in a survey of any magnitude, the intellect will invariably flag in energy before the entire survey is completed. Naturally an effort is made to avoid as far as possible a repetition of work. There is no abridging the inside work, it must be sur-



veyed entire, but we may the outside survey, since the operators and miners wish only to know the location and direction of the most advanced works. It therefore becomes necessary to locate but a few lines on the surface. This has been successfully done by producing the first and last course of a survey to intersection and then calculating the necessary angles and distances. This process requires an immense amount of calculating, and for this reason gains nothing in the element

of time over the old method of running out every line on the surface. In fact it takes more time.

After a most careful study, the following method has been adopted. An accurate map on a large scale, generally 40 ft. to 1 in. is made of the inside survey. All angles are laid off by ordinates, those less than 20° by tangents, the balance by sine and cosine and radius, with the radius not less than 10 inches. There is no known protractor by which angles, for this purpose, can be successfully platted. An engine divided paper protractor may and should be used to test every angle and each course and set of courses that run in one general direction should be repeatedly tested by scale. When the plat thus constructed has been thoroughly tested, certain convenient courses are selected and produced to intersection. The lines thus produced are then measured by scale, and the angles of intersection computed from the deflections of the intervening courses, and tested by protractor.

This process will give absolute results as to angles, and lengths for an entire survey within the fraction of a foot. Test drill holes 2000 ft. from main entrance have repeatedly tested the accuracy of this method. I recently thus ran out a mine line over 5000 ft. long with undoubted evidence that the location was correct.

This radical departure from accepted methods of reproduction, besides its superior facility of execution and greater certainty of results, possesses the great advantage of a careful review, by plat, of the inside survey, the checking out of all chances of error there-from, and the accurate determination of surface lines. It also avoids a monotonous repetition of lines and angles, for the surface work, being as simple as possible, presents a pleasing contrast to the tiresome multiplication of inside angles and courses.

Again all mine surface is badly broken up and set on edge and as by this method you can select your lines at will, you avoid much of the tedious up and down, up and down! work of the old method.

As so much depends upon it, it is apparent that the plat should be made with the utmost care and tested in every particular before trusting its conclusions. In a slope mine there is no trouble in transferring the inside line to the surface as the first sight inside is always transferred at once to the surface. Not so in a shaft mine. Herein the practice of mining engineers has been most reckless. I have known the alignment through a shaft of more than 200 ft. deep to be taken off in 15 minutes. Light plumb bobs are lowered, an average taken of their vibration, and the line started without farther preliminaries. These lines might apparently be in the same vertical plane for their entire length, and yet be 2″ or 3″ out of it due to air currents through the shaft. Rarely does the distance between the plumb lines exceed 5 feet, and an error of 2″ on such a base would produce an error of 65

feet at a distance of 2000 ft. from the shaft. There is usually an air shaft or some other second opening at some distance from the shaft which with the main shaft will give the 2 ends of a base sufficiently large to tie the surface and mine lines to. Of course, as a test, this base should be measured both on the surface and in the mine, and for this purpose it should be carefully plumbed at each end.

Whenever it is absolutely necessary to use the 5 ft. shaft base to connect inside and outside lines the following method is recommended for extending the base at both top and bottom of shaft. Place, in the direction of the first course, a timber over the top of the shaft, 5 or 6 ft. above the ground if possible and let down the two plumb bobs from one edge of the timber at as great a distance apart as possible. When the plumb wires are at rest bring a tightly drawn fish line 15 ft. long into the vertical plane of the wires and drive a stake at a convenient distance from either wire. Repeat the operation until the points on the stakes are exactly in the vertical plane of the plumb wires. This is both quicker and more satisfactory than the usual operation of setting the instrument approximately in the plane of the wires by sighting the nearest wire then removing it to see if other wire is in line. However it is bad practice to use the short shaft base at all, nor should it be used except as a last resort, or where the shaft does not exceed 40 ft. and the extreme workings do not exceed 2000 ft. distance from the shaft.

The extra effort required to secure a long base, will amply reward you in more ways than one.

Band chains have given the greatest satisfaction in mine surveying. The one drawback to their use is that the feet number plates are often carried away in passing the chain through the mine debris, which could be overcome by etching the numbers into the body of the chain as is done in the printed steel ribbons. Roe's aluminum hand chain has no equal in the market. On account of the rough usage and rapid deterioration from sulphur water etc., the printed steel tape is impracticable.

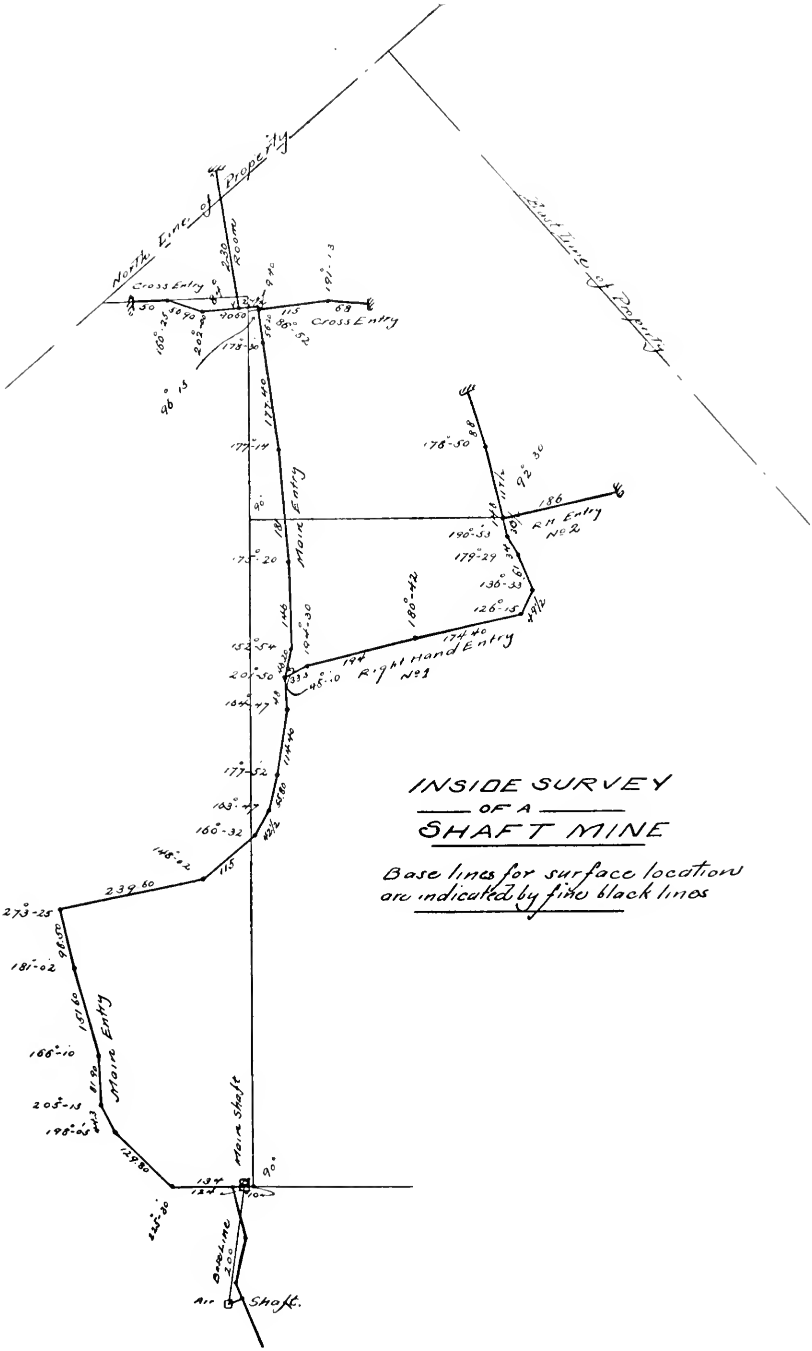
Coal mine work, tho' exceedingly dirty with a tendency to backache, is to those who like it, most fascinating.

DISCUSSION.

Mr. Culley:—This cut is of an actual survey wherein we get a base, main to air shaft of 200 feet. The same precautions are taken to secure the mine and surface ends exactly plumb over one another using three pound bobs suspended by fine wire copper.

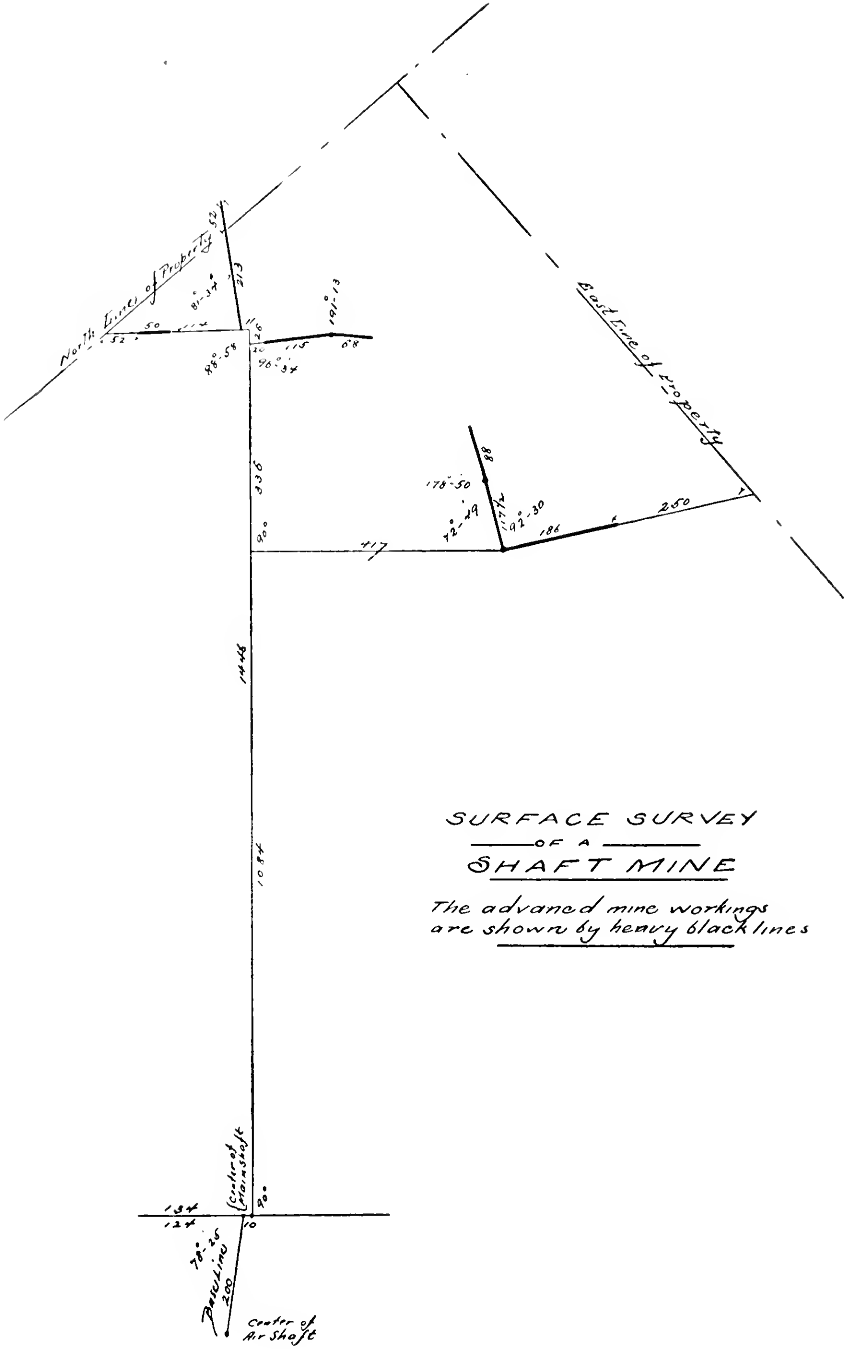
Mr. Rawson:—What method do you use to eliminate vibration?

Mr. Culley:—We use water-usually taking a powder-can filled full



INSIDE SURVEY
OF A
SHAFT MINE

Base lines for surface location are indicated by fine black lines



SURFACE SURVEY
OF A
SHAFT MINE

The advanced mine workings are shown by heavy black lines

of water to completely immerse the bob. Molasses is of course better but not always convenient to have. A mine always has a supply of cans, and water,—usually too much of the latter. Four years since I was called to Wayne Co. this state to decide which of some half dozen different surface locations was correct. Various methods were used to transfer inside work to surface. One surveyor used the magnetic needle and of course was wild in results. Most of the Engineers used the five feet base in a shaft 100 feet deep. It became apparent at once something better than this five feet base must be used to secure a more reliable result than any there on the ground. Hence the invention of long base lines, and I secured a base 764 feet long. A simple calculation will show that the chances of accurate results against the five feet base are, in the drawing, 40 to 1.

MR. BAKER:—I do not see what checks you have to the surface lines—what tests, that they are exactly over the actual inside lines?

MR. CULLEY:—It's true there is material difference in this from the ordinary land survey. There you first make an outline, then a detailed survey and the last is constantly checked by the former. Not so in a mine, the points of checks are few, and you must keep your eyes wide open for them. However you will usually find some surface indications. Surface indications of "faults" will assist, but next to the main and air shafts, drill holes are the best things to tie to.

MR. SWAZEY:—How accurate can this work be put on the large scale drawing? and how close results can you obtain on the surface? also how close can you measure with the protractor?

MR. CULLEY:—In answer to the last question will say we use the protractor only as a rough check on the drawing—the angles of intersection are determined absolute from the deflections of actual observed angles. In answer to your second I will say that thus far I have not yet failed to strike the same point above and below wherever there was any thing to check by, as in the cases cited in the paper, of drill holes 2000 to 5000 feet distant from the base. Where there is no check we must trust in divine providence that the result is O. K. As explained, the drawing should and can be absolutely correct.

MR. EISENMANN:—In answer to Mr. Baker, as to the accuracy of reproduction, the mine and surface survey should be repeated as is actually the case in a careful mine survey. This may be done at once or at different times. When thus located the future surveys will be simple extensions.

MR. PALMER:—In regard to illuminating the cross-hairs of a telescope which had no special arrangements for this purpose, I have tried this very simple method which worked very successfully. A piece of stiff white paper about two and a half inches square bent into a half cylinder is tied on the end of the telescope the same as a shade would

be except that it covers only half the circumference. A light is held just out of the line of sight and near enough to give the requisite illumination. The light is reflected from the concave side of the cylinder into the telescope so there is no trouble about seeing the cross-hairs distinctly. As the full size of the object glass is used for viewing the object the lightness of the field is not in any way diminished.

MR. BARBER:—I have been very much interested in Mr. Culley's paper.

In regard to the difficulties encountered in mine surveying they surpass those of any kind of surveying. In most of the coal mines that it has been my fortune to survey the roof is just a little too low even for a short man to stand erect, the bottom is often wet and muddy, the work usually has to be done at night in order not to interfere with the hauling of the coal, the miner's lamps are usually greasy and supply a liberal quantity of smoke as well as light, some of these little points do not add materially to the comfort of the surveyor.

In regard to laying off the inside workings on the surface I do not think it is a practical thing to do except in some cases where the configuration of the surface will permit and in most cases even then it is better to lay off the surface and inside lines on the same map. Of course, where the surface is all above the mine, as where the mine is entered by a shaft or slope, all that is needed from the surface is the property lines. Where the mine is entered from the side of a mountain or hill, as is the case very largely in this state and Pennsylvania, the crop lines are acquired in addition to the property lines. I remember the first large mine I surveyed. After surveying 35 acres of underground workings the superintendent informed me that he would like to have all the entries laid off on the surface, which in this case was impracticable, if not impossible, as the surface varied from zero to three hundred and fifty feet above the mine and was covered with timber. The running of the crop and property lines was a comparatively easy matter and had the advantage of being exactly what was wanted.

In regard to checking a mine survey in my very limited experience I have found but few mines where long lines could not be tied to drill holes from the surface or some shaft connection, then too, distant points can usually be reached by more than one route which is a check on the inside work.

For setting up a transit in a mine I have used a very small plumb bob suspended over the instrument from the roof, which is very convenient, as the permanent points are usually placed in the roof. I have found this also very convenient in gold and silver mines where the points can be most easily placed overhead on timbers or even on the leaning wall.

Mr. Eisenmann:—On the coast survey we use the following method to light the cross-hairs. Roll up a sheet of writing paper in shape of truncated cone, place the large end over the object glass then cut a circular hole in the middle of cone. The attendant then holds his lamp so as to throw its light into the cone through this hole. This simple contrivance worked admirably and possessed the advantage of giving just the right amount of light. It could be increased or decreased to any desired extent. A small amount of light is all that is needed to bring out the wires. A strong light is almost as objectionable as none at all. Just to bring them out is the desired quantity.

Mr. Howe:—All instrument makers have a small attachment which slips over the telescope tube and has a reflecting surface which throws the light into the tube. This attachment can be turned in any direction so that the lamp can be held on either side. In astronomical work I have found that very good results can be obtained by holding the lamp a few feet in front of the telescope and a trifle one side of the line of vision. Enough light will shine down the tube to show the cross-hairs and that is all that is required. If one is doing much work of this kind it is better to purchase a mining transit which has a hollow axis through which the light shines and thus shows the cross-hairs.

Mr. Culley:—In my early experience I experimented with many of these devices, had special mountings on instrument &c. &c. There is no use for any of them as the hairs can be illuminated better by the simple method I have given. In the cramped position of inside work you want just as few traps and attachments as possible—this is no place to be fussy in I can tell you.

Mr. Gobeille:—This discussion reminds me of the experience of an English friend who wished to locate a shaft exactly over a drift some 2000 feet below. As the undertaking was an expensive one he employed separately three of the most reputable mining engineers. Neither one covered the others point, all were wild of the rest. He then employed three more engineers but with the same result and when he had employed twenty different engineers there were as many different locations. He then took a hand at it. He averaged up the several locations and directed operations to be begun at the center of them all and when the shaft was down it struck the bulls eye exactly.

SAMUEL MORSE FELTON.

A MEMOIR.

By Thomas Doane and Charles Harris,
Committee of the Boston Society of Civil Engineers.

[Submitted Dec. 16, 1891.]

INTRODUCTION.

In submitting this notice of so remarkable a man, one of your Committee, sitting in the same room, into which he entered as student of civil engineering under Mr. Felton 49 years ago, cannot refrain from writing a few lines of personal remembrances. He entered Mr. Felton's office about five years after Mr. Felton had assumed the office of Mr. Loammi Baldwin, and had entered upon the active duties of a civil engineer. During a few years before, and from this time onward, many young men began the study of engineering with him.

His terms were $100 tuition per year, with $2.00 per day of 8 hours, to the student for what work he should do.

Mr. Felton was himself so busily engaged, that he could give very little absolute instruction to his students, but, which was no doubt far better, he succeeded in pushing them out into positions on public works, where they could acquire a practical knowledge of the doing and making of things.

Mr. Felton always regarded his students with interest and affection and followed "his boys", as he called them, along their future professional courses, when within his reach. He was always glad to have them call upon him, and usually dismissed them with a God bless you, and was proud of them when they had done well.

Probably none of his students have reached to his eminence, or usefulness, but Mr. Felton's environments were phenomenal. They are all proud of his abilities, his patriotism and his gentleness.

A notice of Mr. Felton, written by Rev. A. P. Peabody, D. D. of Cambridge, Mass, may be found in the "History of Essex County, Mass." Compiled under the Supervision of D. Hamilton Hurd.

Your Committee would be glad to have the whole of the material which it has gathered, put in print, in an Engineering paper like our *Journal*, as a stimulus to all engineers who may read it, to imitate so worthy an example.

The following matter has been received from those who were intimately familiar with the life and acts of Mr. Felton, and it is gladly received and appropriated by your committee.

A fine steel engraved portrait, and a very good likeness of Mr. Fel-

ton, received from his family, is presented with this notice.* Mr. Felton became a member of this Society Oct. 2nd. 1848, and for many years has been an honorary member of the Society.

MEMOIR.

Samuel Morse Felton was born at West Newbury, Mass., 17th July 1809. He was a descendant of Lieut. Nathaniel Felton, who settled at Salem in 1633, and married Mary, daughter of Rev. Samuel Skelton, the first minister of Salem. His immediate ancestors lived at Salem and Marblehead and, for the most part, followed the sea. His father, Cornelius Conway Felton, had a prosperous business as a wagon-builder at Newbury, Mass., where he married Anna Morse. The rascality of a partner and the depression consequent upon the war of 1812, ruined him and left him saddled with a load of debt from which he was not able to free himself for many years.

The early years of Mr. Felton's life were thus passed in great poverty, and his educational opportunities were very limited. Such as they were, however, he utilized them to the utmost. In the winter of 1815, his father moved from West Newbury to Saugus, and here he attended a school kept by the Rev. Joseph Emerson, paying for his tuition by his labor. Indeed from the age of ten years, he scarcely knew an idle moment, passing his summers in working on the neighboring farms, and his winters in sawing wood, and doing such other labor as his years permitted in order that he might have the opportunity of study. At the age of 14 he entered the employ of a wholesale and retail grocer in Boston, where for four years he filled the somewhat incongruous positions of errand boy and chief clerk. During this time he kept in his desk a Lacroix Arithmetic and a Eulers Algebra, to which he devoted his spare moments. He says of himself that he was not naturally a scholar but was affected by the example of his elder brother, afterward president of Harvard. In 1827, this brother having graduated at Cambridge with high honors, was made principal of the Livingston County High School at Geneseo, N. Y. Here S. M. Felton, having resolved that he too would obtain a college education, followed him and remained for two years, studying and working as clerk and book-keeper in the school. Afterwards to provide himself with a little money he opened a private school at Lyons, New York. This proving successful, he was enabled to enter Harvard in August 1830. His entire worldly possessions then consisted of a cot bed, a few chairs, a table, a lamp, a quart of oil and ten dollars in money. With these, in company with his friend, Joseph Lovering, subsequently

*Your Committee has been unable to find the engraved steel plate, by Ritchie of New York and therefore offers this reproduction as the best substitute it can.

S. M. Felton

Hollis Professor of Natural Philosophy, he left Charlestown, where his father then lived, and drove to Cambridge on a one horse wagon which carried all the property of the two young scholars.

Neither his father nor his brother was in a position to help him much, and he supported himself by teaching. He received assistance also from President Quincy and from a friend of his father's, a tailor named John Bogue, for which, and still more for the kind and considerate manner in which it was rendered, he cherished to the end of his life a lively sense of gratitude. Of his college career he wrote: "The struggles through which I passed for four years were many and various. Poverty, if it does not discourage, is not a bad companion for an ambitious young man, and though I would not choose it for the companion of one of my own children, yet I do not regret the homely and useful lessons I was taught in early youth by its constant contact". In spite of its trials his college career was full of enjoyments on its social side, and he looked back upon it with much pleasure. He was a member of the Institute of 1770, the Hasty Pudding Club and the Phi Beta Kappa Society. Though, as he said, he was no scholar, in the sense of having great literary abilities he possessed a considerable talent for mathematics and graduated in 1834, with high honors, delivering an English Oration at commencement. He was also chosen Orator of his class but declined the appointment. Three years later upon taking a masters degree he was selected to deliver the Latin oration.

After graduating, "he says," I removed to Charlestown, and for two years taught a private school which had been commenced by my friend, Joseph Lovering. When I first went to Charlestown I entered my name as a law student with the late Judge Dana, but finding after a few months that the close confinement of school and the law office was having an unfavorable effect upon my health, I relinquished the study of Law for the no less congenial study of Civil Engineering. I became a student in the office of the late Loammi Baldwin, a man as distinguished in his profession as he was for every manly and noble quality of heart and mind. I became the mathematical teacher of several of his other students and the field practice gave just what I needed in the way of out door exercise. I soon gave up my school and entered actively upon the practice of my profession under the auspices of Col. Baldwin. At his death which took place not long after, I opened an office on my own account in the same rooms which had previously been occupied by him. Here I soon obtained an extensive and lucrative practice. Many students entered with me from time to time for most of whom I at once found constant employment. Many of these young men have since made their mark in their profession and raised to themselves lasting monuments in the railroads and public works they have constructed. Of all the number who were with me

from first to last I scarcely remember one who has not become a useful and honored member of society,"

From another source, an intermittent diary, the following, dated Sept. 4, 1851, is taken. "I commenced to practice civil engineering in good earnest in May 1837, on the Boston and Roxbury Mill Dam in the famous case of Horace Gray and others against the Boston Water Power Co. This was a long and tedious case requiring much accurate observation, much nice instrumental labor in levelling, many experiments at the City mills and much mathematical calculation. All these were gone through with by me with a good deal of vexation at times, but nevertheless a good share of patience and confidence in the accuracy of the results. After the results were made known forthwith they were denounced as inaccurate, and Professor Treadwell, Professor Pierce and W. A. Boyden all investigated the case and pronounced the results erroneous. They proceeded on the old established theory, and on general principles and reasoning from their theory they were correct—but the apparatus used at the mill dam was a peculiar one, the height of the water as let on to the wheel continually varying, and of course no theory which supposed the height of the water to be constant could be correct as applied to this wheel where the element of constant height was not known. After a good deal of discussion and many attempts to set aside the award of the commissioners that award was confirmed by the Supreme Court of Massachusetts and thus my labors and anxieties in this case seemed to be at an end. But the commissioners ordered a measuring wheel to be put in at Gray's works, and I was requested, by Mr. Hayward one of the commissioners, to take charge of the construction of this wheel. The apparatus was to be completed on a certain day by the terms of the award. The weather was cold and stormy and I found it exceedingly difficult to engage a mechanic who would undertake the construction as it was a somewhat difficult and complicated matter. After a long search, I at length engaged Mr. Daniel Leman of Charlestown, a very skillful mechanic, to undertake the task. As we had to work within a coffer dam and were sometimes almost drowned out by the water coming in faster than we could pump it out, I thought that the parties at Gray's works often took a mischievous delight in opening wide their gates and poaring down the flood upon us. Several times we had to retreat in spite of all our efforts to keep the water down. We persevered however, and completed the apparatus on the last day of grace between 11 and 12 o'clock at night. I then continued for a long time to make experiments in measuring the water both at Gray's works and at the Hemp works on the mill Dam and made reports from time to time to Lemuel Pope, Esq., then President of the Boston Water Power Co. These were the beginnings of my career in engineering, a profes-

sion in which I have been as successful as I deserved to be and in which I have enjoyed much and suffered much from exposure and hard work."

In 1841, Mr. Felton made the first survey for the Fresh Pond Railroad, intended for the transportation of ice to Charlestown, and constructed it during that year. The next year he made a preliminary survey upon which the charter of the Fitchburg road was obtained, and was occupied as chief engineer of that work for several years. Upon its completion, in 1845, he became its superintendent and held this position till 1851. In the meantime he made surveys for the Cheshire R. R. and the Rutland and Burlington R. R., was chief engineer of the Vermont Central R. R. and consulting engineer of the Sullivan R. R. and the Ogdensburg R. R.

In February 1851, he was selected, without solicitation on his part, for the presidency of the Philadelphia, Wilmington and Baltimore R. R. Though built upon one of the great thorough-fares of the country, this road had never filled the requirements of the public, nor met with financial success. Its track and equipment were inferior, "necessarily subjecting passengers to delays and annoyances experienced on no other road in the country" said Mr. Felton, in his first annual report, "and making this portion of the great line south and west so uncertain in its time and connection as to be avoided by all who could avoid it, and dreaded by all whose necessities obliged them to use it". In addition its management had, from various causes, been slack and unbusinesslike. Liquor was sold at the various stations; there was no proper system of checks and peculation was rife among the employes; several of them were also engaged in trading in the various articles produced along the line of the railroad and practiced the most glaring discriminations and extortions upon its patrons. "My first effort", says Mr. Felton, "were directed to rebuilding the road in all its parts and to refurnishing it with rolling stock adequate to its wants, and next to developing its resources. I found that its affairs had been entirely managed for eleven years by a man whose talents were more devoted to enriching himself than to increasing the value of the property of the stockholders. He had managed it so as to make a profit individually out of many articles furnished to the road and to control for his own profit many branches of its business. A road thus managed I believed could never answer the objects for which it was built. It could neither accommodate adequately its patrons nor reward its stock holders with fair dividends. After an infinite amount of trouble and enduring untold personal abuse, I succeeded in displacing this man from his position, and, as soon as the road had paid from its earnings the debt necessarily incurred in its remodelling, it at once took its place among the dividend paying institutions of the country."

The person here meant was the superintendent of the road, a man of much ability and influence, both social and political, and possessing the confidence of many of the leading men of Philadelphia,—charges against him were formally preferred and investigated by a committee of five of the board of directors, three of whom at least were warm personal friends of the superintendent. Before this body Mr. Felton conducted a long and arduous examination, with an ability which extorted admiration even from his enemies. Local prejudice and jealousy of New England then prevailed to an extent now happily unknown and of these the superintendent and his friends took full advantage. Mr. Felton was obliged to face a storm of "untold personal abuse", of public and private calumny and of attempted diversions in the City Councils of Philadelphia and Baltimore and the Legislatures of Maryland and Pennsylvania. All of this unjust suspicion and obloquy wounded Mr. Felton deeply but he persevered and in the end succeeded in breaking the power of the ring that had so long robbed the stockholders of the railroad, and oppressed the people commercially dependent upon it.

In his first annual report Mr. Felton urged the bridging of the Susquehanna. "It is", he said, "an improvement demanded by travellers and one which they had a right to demand. The expenditure will be heavy, but the company should not hesitate to make it; for every expenditure incurred to insure speed and certainty and to lessen the vexations and expenses to which the traveller is subjected will bring a corresponding return". An application was accordingly made to the Legislature of Maryland for a charter to build the bridge, but, as usual in such cases, this proposition met with much opposition. Mr. Felton, in reply, pointed out its great importance to the state of Maryland. It would, he said, by drawing travel from the west over the Baltimore and Ohio R. R. give a large direct return upon the stock held by the state in that road, and would in addition be of great benefit by bringing western and southern travellers, that then sought other routes, through the city of Baltimore. A charter was accordingly granted and work begun upon the bridge, but it was not possible, owing to business depression to continue it then, and the bridge was not finally completed till 1866, when Mr. Felton had retired from the presidency.

When Mr. Felton took the presidency of the Philadelphia, Wilmington and Baltimore R. R., the traveller between New York and Washington was compelled to purchase tickets and recheck his baggage in every city. Almost his first efforts were directed to establishing a system of through tickets, but so unprogressive was most of the railroading of that day, that it was a considerable time before he could bring about such facilities on any except the night trains. He also from the first endeavored to establish direct connections in the cities,

and through freight rates. In 1853, upon the opening of the Baltimore & Ohio, through to the west, Mr. Felton endeavored to make through freight arrangements with that road. But the management then in control refused to entertain such a proposition on the ground that their road had been built by Baltimore and should be used for the benefit of that city alone. Commenting probably on this policy he says, in his report for 1853., "To insure our share of this business we must become one in interest and make our line as quick and cheap as any other, commenceing at New York and ending as far west as a railroad or a steamboat reaches. Local considerations and local jealousies must be forgotten, or our more active neighbors will be successful in the contest and win for their prize the business of the exhaustless west. No city can hope to attract business to itself by imposing restrictions upon trade and travel in either direction", such words as these, written at a time when the immense possibilities of railroad transportation, and the methods of utililzing it were but dimly comprehended, are not without interest.

In 1852, Mr. Felton became interested in a project for building a railroad from Dover Landing on the Delaware River through the peninsula to the Chesapeake. This he perceived might become a rival route to the South, and not only a regard for the interests of his own road, but a settled disapproval of the building of parallel roads in general urged him to change this plan if possible. He accordingly made a proposition to the projectors of the Delaware line to unite with the Philadelphia, Wilmington & Baltimore Railroad, and gave them substantial assistance in finishing their road. Although the terms under which the Delaware Railroad was leased resulted for some years in a considerable annual loss in its operation, Mr. Felton was confident that its immediate value as a feeder and the great possibilities of growth which he foresaw would more then repay any expense which might be incurred. He says; "The road promises to repay its stockholders and all others who have contributed to its construction for their labors and sacrifices. It opens a fertile and healthy country, heretofore inaccessible, to the great markets of Philadelphia and New York. It will soon become as productive in fruit and early vegetables as the vicinity of Norfolk or the lands along the railroads in New Jersey. Its forests of white oaks will furnish the best of timber for ship building and for cars. Delaware is also an extensive grain growing country and the facilities of railroad communication will largely increase its products in this department. The business of the whole peninsula will now be made tributary to our road, and while the wealth of the country will be quadrupled by the construction of the Delaware Railroad there will be no doubt that we shall reap a fair share of profit for our expenditure and risk". The result has amply justified this forecast

and in particular the immense growth of the fruit business of the peninsula may be said to have originated with the opening of this road. In recognition of Mr. Felton's services the legislature of Delaware by resolution named a town upon the new railroad for him and this is now one of the largest fruit shipping points in the state.

In his annual report for 1856, Mr. Felton says "For several years past the system of operating railroads by contract has been discussed in this country but it has not been adopted to any extent. Since August of last year it has been more extensively tried on our road than heretofore and has been found to work well. All the trains are now run at a stipulated price per mile including repairs and renewals of locomotives, fuel, oil and waste and wages of engineers and firemen. The labor of repairs on road is also furnished by contract. The Freight business is paid for by the ton, in all its details including loss and damage, and wages of conductors and brakemen. The fuel for the stations, shops, steamboats, cars and for the ferry is furnished for a stipulated sum per year. This system more than any other brings to bear upon the affairs of the company the element of individual responsibility, the true element of success in any business". The next year, after a still further extension of this system, he says "nothing can more effectually secure promptness, energy and thoroughness than this system properly carried out in the hands of faithful contractors. Everything however depends on the selection of capable, honest and efficient men. Too great a subdivision of the work by contract among many disconnected parties might also work to great disadvantage. * * * * Our trains have never run with so much regularity as now and our road, cars and engines have never been in so good order. We do not mean to say that this state of things could not have been brought about under the old system, but we are certain that it could not have been accomplished so cheaply and so easily as under the contract system. * * * * Private corporations succeed generally better than state governments in the management of public works, because individual care and interest can be better called into action, but even here that keen vigilance in all departments, and particularly in the expenditure of money, which is the true element of success in private business can rarely be attained. If all the employees of a corporation could be made pecuniarily interested in its economical and safe management, its success would be more certain, extravagant expenditures would be avoided and accidents would be much more rare. A proper contract system secures all these important objects when faithfully carried out by competent men". Indeed in Mr. Felton's hands this system fully justified his expectations, the operating expenses of the railroad for the year 1859, when it was in full operation, being only 37½ per cent of its receipts, a record which, it is believed, can

scarcely be paralleled elsewhere either at that time or since.

Another economy for the earliest practical demonstration of which the railroad world is indebted to Mr. Felton was the use of coal-burning engines. While superintendent of the Fitchburg road he had been interested in experiments in burning coal, and it had been used in some places, notably on the Philadelphia and Reading road for freight engines. But the engine "Daniel Webster," placed on the Philadelphia, Wilmington & Baltimore R. R., in April 1857 was, it is believed the first successful coal burning passenger engine in regular service upon any railroad in the United States.

Mr. Felton was, if not the first at least one of the first to make the running of a railroad the subject of serious and scientific study and to formulate the principles upon which it should be conducted. For many years he collected and bound together all the railroad reports issued in the United States, and gave to them the most painstaking and careful study. He had thus not only a practical experience in railway management but was Master of its theoretical side as well. Many of his annual reports contain discussions of the principles of railway operation which show how wide was his acquaintance with these problems and how correct was his understanding of them. This he had worked out almost entirely for himself.

By the year 1859, Mr. Felton had brought the Philadelphia, Wilmington & Baltimore R. R., to a condition of such efficiency that it was very generally recognized as one of the model railroads of the time. The Railroad Journal in that year said of it. "Almost every circumstance connected with this road is against its being cheaply operated. Till the reforms now introduced were made the current expenses did bear a very large proportion to the gross receipts, with them the road now shows more favorable results than any other in the country." His reputation had become so high that his services were sought by many other railroads. The stock holders of the Baltimore and Ohio several times sought to make him president of that corporation. It is perhaps worthy of note, as showing Mr. Felton's excellent judgment of men, that on one of these occasions when he was urged by Mr. John W. Garrett to take this place, he suggested that Mr. Garrett himself could fill it excellently, and that it was in consequence of this that Mr. Garrett who had not previously had any expeiernce in railway management took the position in which he subsequently made so great a name for himself. "In the autumn of 1860," says Mr. Felton, "I was offered the largest salary then paid in the country to take charge of the Philadelphia & Reading R. R., and accepted the offer provided the representatives of the Philadelphia, Wilmington & Baltimore R. R., would consent to my leaving. This they declined to do, and requested me to name a salary that would induce me to remain. I told them that they al-

ready paid as much as they ought and that they could now obtain a man who could manage the road as well as I for a smaller sum than they paid me, but all to no purpose. As in all my troubles and labors they had always nobly sustained me I determined that I would not leave excepting with their full consent and I therefore named a sum one-third less than I had been offered and so consented to remain."

Not long afterwards came the election of Mr. Lincoln and with it the signs of the coming storm. The exposed position of Washington, cut off from the north by the slave state of Maryland, and from railway communication by the ardently southern city of Baltimore, was such that it could hardly fail to attract an attack. The situation of the Philadelphia, Wilmington & Baltimore R. R., as the chief avenue of communication between Washington and the north with more than half its length in Maryland made it an important factor in any contest which might arise for the possession of the capital, and in fact gave Mr. Felton an important part to play in the opening scenes of the war.

Toward the end of December 1860, in an interview with the late Miss Dix, the Philanthropist, who had been for some time engaged in charitable work in the southern states, he was apprized of facts indicating a well defined intention to seize Washington. This scheme of course included the breaking of railway communications with the north. The Philadelphia, Wilmington & Baltimore R. R., was particularly exposed owing to the long trestle bridges by which it crosses Bush and Gunpowder Rivers, estuaries of the Chesapeake. From this and some other information Mr. Felton was led to believe that there was danger that an attempt would be made to prevent Mr. Lincoln's inauguration. His first step was to send his information, together with some suggestions as to other routes, to Gen. Scott, and to ask protection from the government. But this could not be obtained. Mr. Felton next called the attention of Kane, the Marshal of the Baltimore police, to the matter and requested an investigation. But that official merely ridiculed the matter and entirely declined to lend his assistance. Mr. Felton therefore employed private detectives to join the various military companies in and about Baltimore, and organized and secretly drilled a force of men who were ostensively employed in coating the bridges with whitewash, which was saturated with salt and alum to render the piles as nearly fireproof as possible. In the meanwhile rumors had reached the officers of the road that a conspiracy to murder Mr. Lincoln was being hatched in Baltimore.* These rumors were investigated and found to be true. Upon the arrival of Mr. Lincoln in

*Some account of the conspiracy to assassinate President Lincoln, which is alluded to herein, may be found in recollections of President Lincoln and his administration "by H. E. Chittenden, Register of the Treasury," Chapters X and XI.

Philadelphia. on the night of the 21st, of February 1861, the details of the investigations were laid before him and he was urged to proceed at once to Washington. But he declined to alter his programme, which was to go to Harrisburg and proceed thence by way of the Northern Central R. R., to Baltimore and Washington, excepting that he agreed that if no delegation from Baltimore met him at Harrisburg he would return the next night to Philadelphia, and go through secretly to Washington. When he was returning to his room he was met by Mr. F. W. Seward with details of another and entirely independent investigation, conducted in behalf of Mr. Seward and Gen. Scott, which pointed to the same conclusions. He now, as he says, felt convinced that such a conspiracy was in existence. Accordingly it was arranged that he should take a special train the next night from Harrisburg, and the regular night train from Philadelphia south.

Meanwhile Mr. Felton arranged the details of getting the president-elect safely through Baltimore. Upon the pretext that he had a package of important documents to be delivered in Washington, he requested the officers of the Baltimore & Ohio R. R., to delay their train south so as to be sure of the connection, and used the same excuse to delay the train at Philadelphia beyond its appointed time of starting. Mr. Lincoln was met at West Philadelphia by one of the officers of the Philadelphia, Wilmington & Baltimore R. R., with a carriage, and driven to the Baltimore station. When he was aboard the train, the important package which consisted of old R. R., reports, was put in the hands of the conductor and the train started. One of the officers of the P. W. & B. R. R rode upon the sleeping car to Baltimore, and another from there to Washington.

Simultaneously with the departure of Mr. Lincoln from Harrisburg all the telegraph wires at that place had been cut, and with them those connecting Philadelphia with the south. At eight o'clock, on the morning of Feb. 23rd, they were joined and the first message they bore was to Mr. Felton, "Your package has arrived safely and been delivered."

Of course highly colored and sensational stories of this episode filled the newspapers. Among these was a story of Mr. Lincoln's wearing a scotch cap and a plaid cloak as a disguise. In this, as in many others of these stories, there was no truth whatever. Equally of course the existence of a conspiracy to assassinate Mr. Lincoln has been the subject of a good deal of controversy. In the nature of the case, the evidence of such a plot can hardly be conclusive since it may mean much or little according to the amount of resolution of the plotters which nothing but the event can determine. The story of the detective may be found in an article by Mr. Arnold in Harper's Magazine for June 1868. It shows a well arranged plan to assassinate Mr. Lincoln in the confusion upon his arrival at the station. The men to do the act were de-

signated and arrangements made for their escape. To this story but two objections have been made, first that the person chiefly accused, one Ferrandini, was a barber, and hence a person incapable of committing crime, and several that the detection was actuated by the temptation of earning a reward and making a sensation. It is true that Ferrandini was a barber, but he was also a person of sufficient importance to be called as a witness before the committee of Congress which investigated the disloyal military organizations in Maryland, to one of which he acted without compensation as drill master. His testimony which corresponds very well with the detectives account of him, shows him to have been something of an adventurer, and that he had held a commission as captain in the Mexican Army under Juarez. As to the other objection, the detectives bill for his services shows that he and his assistants were not tempted by the offer of a reward, but were paid by the day, regardless of the discoveries which they made. Moreover the detective, far from endeavoring to make a sensation, kept perfectly silent as to his part in the matter for more than six years, and then only came forward to answer an attempt by Mr. Seward's detective to take all the credit of the transaction.

After Mr. Lincoln's inauguration the detectives and the bridge-guards were dismissed, and matters proceeded in their regular course till the fall of Sumter, and the President's proclamation. It was, as shown by the Report of the Committee of five, the avowed intention of the bands and companies organized about Baltimore to prevent the passage of any troops from the North. Many persons warned Mr. Felton of the impending destruction of his road and urged him not to transport any troops. A note from the Police Marshal of Baltimore to the agent of the road asking if it was true as stated "that an attempt will be made to pass the volunteers from New York intended to make war upon the South over your road to-day?" Mr. Felton sent to the War Department, and to a communication from one of the Directors of the Road in Baltimore, urging him on no account to attempt the passing of troops over the road, he replied that he had no right to refuse to transport them, that the temper of Philadelphia was such that no such refusal would be tolerated and finally "I do not hesitate to decide upon my duty in this trying hour. It is to stand by the government and abide the consequences. I shall, therefore endeavor to do, to the best of my ability what is required of me. If our road is disabled the responsibility must rest upon the wicked persons who do the deed and a terrible retribution will certainly await them."

It was now the eventful 19th. of April 1861. An attempt had been made to arrange for the transportation of the expected troops across the harbor of Baltimore, but it had not succeeded owing to lack of time. At 3 o'clock in the morning of that day the Massachusetts Sixth left

Philadelphia. Says Mr. Felton, "Before they started I called the colonel and principal officers into my office and told them of the dangers they would probably encounter and advised that each man should load his musket before leaving Philadelphia so as to be ready for any emergency * * * * The regiment started and I stood by the telegraph instrument in Philadelphia constantly receiving messages of its progress. Finally it was announced from Baltimore that they were in sight, next that they were received at the depot with cheers. Then that ten car-loads had started for the Camden St. Station and all was right. Then that the other four car-loads had started and turned the corner into Pratt St. all right. Then after a few moments that the track was torn up in front of them and they were attacked on Pratt St. Then the reports subsided into mere rumors and we could not tell whether the mob or the troops were to be successful. Then came the news that the mob had turned upon an unarmed regiment (Col. Small's) which had left Philadelphia with the Massachusetts Sixth; that the mob had mounted the tops of the cars and were breaking them in and throwing down paving stones and other missiles on the heads of the volunteers and chasing those who left the cars through the streets of the city. The excitement, anxiety and oppression that I felt at this moment may be better imagined than described. At this juncture I received a message from the Mayor and Police Commissioners of Baltimore as follows, in substance, "withdraw the troops now in Baltimore and send no more through Baltimore or Maryland" * * * In order to get time to ascertain more exactly the condition of affairs, I telegraphed back to them that I had received such a message as the above, and asked "is it genuine?" In the meantime, I ascertained that the bulk of the Massachusetts Sixth had just got through and were on their way to Washington, and believing that the mob would murder the unarmed men under Col. Small if I allowed them to remain where they were and that our bridges between the Susquehanna and Baltimore would be at once destroyed and that some other route must be adopted, I bethought myself of the Annapolis scheme before communicated to Gen. Scott. I therefore telegraphed to the Mayor of Baltimore. "I will withdraw the troops now in Baltimore and send no more through the city till I first communicate with you," making no allusion to Maryland but so wording my despatch that they would conclude that no more troops would be sent and be unprepared to throw any obstacles in the way of the Annapolis route."

It was now about 3 o'clock in the afternoon. Orders were immediately sent to the Captain of the Ferry-boat "Maryland" at the Susquehanna, to lay in a supply of coal and procure a pilot who knew the harbor of Annapolis. Then in company with Mr. J. Edgar Thomson, who had been appointed an Agent of the War Department, Mr. Felton

set about collecting a fleet of transports at Perryville on the Susquehanna. They also telegraphed to Washington for authority to send troops by Annapolis, but could get no reply. About five o'clock a conference was held at the house of Gen. Patterson commanding the Department, where after full discussion the route by Annapolis was adopted by the political and military authorities.

During this time the Massachusetts Eighth Regiment under Gen. Butler had reached Philadelphia; and the New York Seventh was expected. About twelve o'clock that night, Mr. Felton sought an interview with Gen. Butler. Gen. Patterson, as the troops were not yet mustered into the service of the United States, had no authority to order a change of route, and it therefore became necessary for Mr. Felton to argue the matter out. For this purpose, he took Commodore DuPont with him to see Gen. Butler. What took place may be told in Commodore DuPont's words: "I had returned late at night from a day of arduous labor at the Navy Yard to the La Pierre House where I met you, when you asked me to accompany you to see Gen. Butler who had arrived in the evening with the Massachusetts Eighth Regiment.

"On seeing the General, you informed him that you had received a telegram from Governor Hicks requesting you to send no more troops through Baltimore. Gen. Butler promptly replied, "If Col. Lefferts (the New York 7th, had also arrived in Philadelphia) will join me we will fight our way through." You then told the General that you expected to hear at any moment that the bridges had been burned, (which did occur), and that you had come to propose forwarding him and his Regiment by way of Annapolis employing the company's large ferry-boat for that purpose. You then mentioned the object you had in asking me to accompany you that I might give Gen. Butler accurate information as to his landing at Annapolis, adding that you had intelligence from Washingthn, from reliable sources, which represented the capital in a most defenceless condition."

After some further discussion, Gen. Butler agreed to act upon Mr. Felton's suggestion. Early in the morning of April 20th the expected news of the burning of the bridges arrived. Major Trimble, a former Superintendent of the railroad, had seized a train and compelled the engineer at the point of his pistol to carry him on his work of destruction. He probably intended also to attach the ferry-boat "Maryland" at the river, but was frightened from his purpose by the conductor and engineer who told him that trains were closely following them from Philadelpnia with a large force of troops. He therefore desisted and returning burnt the bridges over Bush and Gunpowder rivers, thus completely disabling the forty miles of railroad between the Susquehanna River and Baltimore. In this Major Trimble was acting under the orders of the Mayor of Baltimore and the Governor of Maryland.

who appear from the narratives printed in the Official Records of the war, to have implicitly obeyed the secession element in the city.

In the meantime, the New York Seventh had arrived in Philadelphia and Mr. Felton tried to persuade Col. Lefferts to proceed to Annapolis with Gen. Butler. But in the unfortunate absence of orders from Washington, jealousies arose and Col. Lefferts determined to proceed down the Delaware and by sea, a longer and slower route. Both of them started from Philadelphia at about the same time on the afternoon of the 20th, of April, Col. Lefferts, however, did not reach Annapolis until some thirty-six hours after Gen. Butler though, owing to the latters having run aground in endeavoring to tow the ship "Constitution" out of the harbor, he was the first to land.

In the meanwhile, Mr. Felton and Mr. Thomson had, on their individual responsibility, collected all the available transports at Perryville. Provisions for the soldiers were procured at the expense of the railroad, and sent to Annapolis, and engines, cars, railroad iron, coal, horses, carts and laborers were procured by Mr. Felton and dispatched to Gen. Butler. From the necessary expenditures, amounting to many thousands of dollars and made without authority, many men would have shrunk, but with Mr. Felton the safety of the capital was the paramount object. By these exertions a route was opened over which the thronging regiments from the loyal states were sent to Washington, which they reached just in time to check a descent which was preparing in Virginia and the South. The best opportunity that the confederates ever had to capture Washington and make the Susquehanna instead of the Potomac their boundary had passed away never to return.

Now began a four years period of struggle against overwhelming difficulties which, though successful, cost Mr. Felton his health. Situated as he was almost at the focus of public attention, he could not escape much honest criticism and more that was designing and insincere. Not long after the beginning of the war a vigorour effort was begun to induce the government to build another line of railroad from Washington to New York, or to lend its aid to the speculators who wished to embark in such a project. The non arrival of the mail on schedule time was the text for a tirade against railway monopolies. If a single train failed to make connection a loud clamor began about the discomfort and imperfections of the existing line. One just subject of criticism there was—the necessity of a transfer across Philadelphia, and the bad connections in that city. But this was not Mr. Felton's fault but the fault of those local jealousies against which he had protested during his whole career as a railroad man. Every attempt to remedy this evil, however brought upon his head a storm of injunctions, of criticisms and of resolutions whose burden was that he intended to make Philadelphia merely a way station on the road to New York. Bills to secure

government credit for the projected railroads were several times introduced and powerfully supported. Against these Mr. Felton made argument after argument, pointing out with all the force at his command that the situation was abnormal, that with the close of the war traffic would subside to its usual volume, which could not support two routes, and that the government having unjustly confiscated the property of those who had invested in the existing railroads, would find itself burdened with a road which could hardly pay its operating expenses. These arguments prevailed but not without strenuous exertions on Mr. Felton's part.

The mere labor of conducting the immense and spasmodic business of the government with the railway appliances of that day was enormous, but all of this was under the personal supervision of Mr. Felton. Moreover the demands of the government made skilled labor the scarcest of commodities. Enginemen and machinists entered the government service and their places had to be supplied by men possessing less skill and experience to the severe derangement of railway operations. Again the necessities of war caused great scarcity of materials of every kind. The quality of railway equipments rapidly degenerated, and towards the end of the war it became almost impossible to procure even inferior locomotives and cars at any price.

Under such circumstances accidents were necessarily of frequent occurrence, and to Mr. Felton, working under a storm of unjust criticism, each one was the cause of the utmost anxiety and distress. No man could be more exacting toward himself nor feel his responsibilities more deeply than he. It is little wonder, therefore, that after passing through an unusually severe winter, that of 1864, when the bridge over the Schuylkill at Grays Ferry was burnt, and successive ice-freshets in the Susquehanna almost stopped travel for days at a time, and excessive labor disabled most of the officers of the railroad so that the whole burden fell upon the president, that his health was undermined and in the following autumn he suffered a shock of paralysis which compelled him to retire from work.

It is worthy of note that the first hospital cars for the transportation of sick and wounded soldiers were constructed upon the plans of the sanitary commission, by the Philadelphia, Wilmington & Baltimore R. R., and used upon its line thus originating a service of untold value in the alleviation of suffering, and the saving of life. No person in the service of the company ever was interested in any government contract, but in the words of Gen. Patterson written to Mr. Felton "with you and with the officers of the railroad under you, to sustain the government appeared to be a labor of love."

Almost a year of rest so far restored Mr. Felton's health as to permit him to enter once more upon active life. In September 1865, he became

President of the Pennsylvania Steel Co., the first concern in the United States to attempt the manufacture of steel rails as a commercial undertaking. It is very rarely that the pioneers of a new field of enterprise survive to enjoy its success, but the Pennsylvania Steel Co., has proved an exception to the rule and has grown to be one of the largest concerns of its kind in the United States. While engaged in the management of this corporation Mr. Felton was not inactive as a railroad man. He served as director of many railroads, among them the Philadelphia, Wilmington & Baltimore R. R., the Lehigh Coal & Navigation Co., the Northern Pacific, the Ogdensburg & Lake Champlain and several others. For ten years he was a director of the Pennsylvania R. R., and bore a considerable, though inconspicuous, part in the development of that great corporation. The only employments of a political nature which he ever held were that of a Commissioner of the Hoosac Tunnel from 1862 to 1865 by appointment of Gov. Andrew and that of a Commissioner to inspect the Pacific Railroads upon their completion in 1869 to which he was appointed by President Grant. Shortly after his retirement from railroading, he was asked by the representatives of both political parties at his home, to accept an election to Congress, but this he declined.

In 1881, the infirmities of age began to be felt by Mr. Felton and he gradually gave up all his positions excepting the presidency of the Pennsylvania Steel Co., and that of the Delaware R. R., Co., the duties of which he was able to discharge until a short time before his death. His last days were passed with a cheerful and serene mind, though in gradually failing bodily health. Just before midnight on the 24th. of January 1889, he passed away, without enduring any suffering other than that inseparable from weakness and prostration of body. It is given to few men to win as he did a marked success as a teacher, as an engineer, as a railroad president and as manufacturer. Fewer still perhaps enjoy so entirely the respect, the confidence and the affections of all who know them. And with him those who knew him best honored him most.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

MONTANA SOCIETY OF CIVIL ENGINEERS.

FEBRUARY 13, 1892:—The regular Monthly Meeting of the Montana Society of Civil Engineers was held Feby. 13, 1892. Meeting called to order at 8 P. M. Mr. Keerl in the chair.

Present: Messrs. Hovey, Cumming, Sizer, Wheeler and Jones.

Minutes of the Annual Meeting were read and approved.

Application of Mr. Thos. Weir was read and referred to the Board of Trustees. Application of Mr. Gutelius was read a second time, and said application having received the approval of all Trustees, a ballot was ordered but the issuance of said ballot was ordered deferred for one month.

Mr. Keerl, as chairman the Committee on connection lines of mineral surveys, reported progress. Being somewhat in doubt as to what were the Society's views upon the subject, he invited a general discussion. The Committee was then allowed further time and Mr. Keerl promised to submit a report with the views of the Society incorporated therein at the next monthly meeting.

The Committee on Senator Power's Bill No. 663 then asked permission to withdraw its former report, as it desired to amend former recommendations in regard to the rates of mileage allowed, by increasing and classifying same. On motion the request of the Committee was granted and the report was withdrawn.

The chairman then invited general discussion as to what rates should apply and after considerable argument pro and con, the following rates were settled upon.

Minimum	$14	$10	and $8
Intermediate	$22	$16	and $13
Augmented	$25	$23	and $20
Maximum	$30	$28	and $24.

The reading of a letter from Mr. E. L. Corthell, Chairman of the General Committee of Engineering Societies at the Columbian Exposition, was dispensed with. Mr. Keerl having carefully read the letter, gave a brief resume of it, and upon motion, it was ordered that said letter and the documents accompanying it be forwarded to Mr. E. H. Wilson, Society's representative at the Columbian Exposition for any suggestions that he might have to offer.

Upon motion it was ordered that the Secretary remit to John W. Weston, editor of the Journal of Associated Societies, as soon as the funds

of the Society would permit. The Secretary was also instructed to subscribe for index to said Journal.

Upon motion, Ex-Secretary Keerl and Treasurer A. S. Hovey were allowed to withdraw their reports for the year ending Jany. 9. 1892, in order to correct a clerical error therein.

Upon motion, duly seconded, the Society adjourned until their next regular meeting.

F. D. JONES, Secretary.

MARCH 12, 1892:—The Regular Meeting of the Society of Civil Engineers was held on March 12th, 1892, in the office of Messrs. Sizer & Keerl. The meeting was called to order by 2nd Vice President J. S. Keerl.

Members present:—Foss, Mc. Rae, Smith and Heron. Mr. Alexander as a visitor.

Minutes of last meeting were read and approved.

Mr. Weir's application was read a second time and ballots were ordered to be issued for both Mr. Weir and Mr. Gutelius.

Committee on Connection lines reported progress and stated that Mr. Wilson promised to write his views on this subject, but at this date no report had been received. Mr. McRae also reported that he had some features which he wished to incorporate.

Moved that Committee be granted further time in order to include the views of Mr. Wilson and Mr. McRae.

Committee on Public Surveys read their report. It was moved, seconded and carried that the report be referred back to the Committee for further consideration, and that they be requested to report at a called meeting of the Society to be held on March 26th, 1892.

On motion duly seconded and carried, it was ordered that a copy of Mr. Wilson's letter relative to the Columbian Exposition be forwarded to the alternate.

Moved and seconded that the correspondence relative to the Convention to be held in Paris, looking to the improvement of canals and waterways be referred to the Board of Trustees.

The Secretary was instructed to notify members in arrears for dues since 1892 that under the By-Laws of the Society they were liable to the penalty of suspension.

Moved, seconded and carried that the Society adjourn subject to the call of the Secretary.

F. D. JONES, Secretary.

BOSTON SOCIETY OF CIVIL ENGINEERS.

FEBRUARY 17, 1892:—A regular meeting was held at the American House, Boston, at 19:45 o'clock. President Stearns in the chair. Fifty-seven members and twenty-eight visitors present.

The record of the last meeting was read and approved.

Messrs. Frank A. Barbour and William P. Flatley were elected members of the Society.

The Secretary read a communication in relation to the International Engineering Congress to be held in connection with the World's Fair in 1893, giving the general plan as proposed by the Executive Committee. The communication was received and placed on file.

The President appointed as the tellers to canvass the ballots for officers at the annual meeting, Messrs., Dwight Porter and A. G. Robbins.

Mr. John A. Coleman of Providence, exhibited and explained a device for a catch-basin trap. The Perpetual Seal Trap, as it is called, is a single casting which may be applied to any existing form of city catch-basin without change of brickwork. The advantages claimed for this trap are, that the sewer is never untrapped even when the men are cleaning the basin and that the expense of refilling with water to maintain the seal is saved.

Mr. William E. McClintock read a paper on Highway Construction, speaking particularly of the rock formations found in the different parts of the state which are available for road metal.

Mr. F. E. Foss of the Institute of Technology read a short paper upon the Course of Instruction in Highway Engineering at the Institute.

Mr. Henry B. Wood read a paper prepared by Mr. Charles R. Cutter giving an outline of the work done by the Paving Department of Boston and described the method of laying macadam in use in Boston.

Mr. Wood then read a paper prepared by himself giving the results of experiments made during the past year with various kinds of brick pavements in Boston. He also described the methods of street cleaning and street sprinkling used in Boston. Mr. Wood had thrown upon the screen a large number of views illustrating the condition of the streets and pavements in various cities of the country which he had gathered in a recent trip.

Mr. E. W. Howe spoke of the method of road building used in the Boston Parks and gave some items of the cost of building and maintaining.

Mr. Henry Manley gave an account of the paving work done by contract on the streets of Boston during the past year.

After examining a model of a sprinkling cart for one horse used in Paris, exhibited by Mr. H. D. Woods, the Society adjourned.

S. E. Tinkham, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

363d Meeting. April 6, 1892:—The club met at 8 p. m. at the club rooms, President Johnson in the chair, twenty-three members and two visitors present. The minutes of the 362nd meeting were read and approved. The executive committee reported the doings of its 128th meeting.

Messrs. A. A. Stuart, C. B. White and T. L. Condron were elected members of the club.

Capt. C. F. Palfrey was proposed for membership.

Prof. Potter reported that at a meeting of the citizens' committee for the abatement of the smoke nuisance, an executive committee of fifteen had been appointed. The executive committee had organized and elected the following officers: President, D. L. Kingsland; vice-president, C. H. Sampson; treasurer, S. M. Kennard; secretary, C. H. Huttig. Articles of associtiom had been drawn up and all interested in the subject would be given an opportunity to join.

Mr. E. A. Hermann then read the paper of the evening, on "Steam Shovels and Steam Shovel Work."

The steam shovel is not a very old machine; its general use dates from about 1875. The steam shovel for railroad use only differs from

those for general work merely in being mounted on standard gauge trucks. The machinery of a steam shovel works either through positive gearing or through friction clutches. The latter works more rapidly and is better adapted to softer materials, but heats the clutches easily, often causing delays. The positive gearing machines are a little slower but more reliable, especially for hard material. Steam shovels vary in capacity of dipper from ½ to 2 cubic yards. The sketches showed manner of making cuts of different depths and widths; also showed the plow and spreader, and manner of using them, for unloading and distributing the material loaded on cars by steam shovels.

Discussion followed by Messrs. Crosby, Hermann, Ockerson, Wheeler.

Mr. Perkins described an instance of the delivery pipe from a boiler becoming choked with scale. Col. Meier cited an instance where the intrainment was 14 per cent.

A discussion on the purification of the city water was taken part in by Messrs. Seddon, Potter and Johnson.

Prof. Johnson exhibited the first scientific book on the truss bridge, entitled "Bridge Building," by S. Whipple, published in 1847.

For the next meeting, April 20, a paper by Mr. B. F. Crow on "Elements Involved in Rapid Transit" was announced.

Adjourned, ARTHUR THACHER, Secretary.

364TH. MEETING. APRIL 20, 1892:—The club met at 8 p. m. at the club rooms, President Johnson in the chair. The minutes of the 363d meeting were read and approved. The Executive Committee reported the doings of its 129th meeting. Capt. C. F. Palfrey was elected a member of the club.

Mr. B. F. Crow then read the paper of the evening on "Elements Involved in Rapid Transit." The subject was divided into two parts, first, the development of a new system, and second, the study of methods to increase the efficiency of lines already in existence. The second method is the one in which the greater number are interested. One of the greatest drawbacks to rapid transit has been the poor roadbeds and poorly designed curves which answered the purpose for the horse cars but were inadequate for the present system The terminal facilities was another point which made trouble when it was attempted to run a number of trains with a small headway. The question of stops was one which presented serious difficulty to obtaining any high rate of speed. The paper also dwelt on the question of car construction and showed some of the advantages obtained by newer and better designs.

Discussion followed by Messrs. Hermann, Crow, Seddon, Moore, Johnson, Crosby, Olshausen, Maxon, Colby, Russel, Woods.

Moved that the Executive Committee be requested to submit a list of papers that they think desirable for the club to subscribe for.

A paper by Prof. Howe on "The Maximum Stresses in Drawbridges" was announced for the next meeting, May 4.

Adjourned. ARTHUR THACHER, Secretary.

WESTERN SOCIETY OF ENGINEERS.

289TH. MEETING. MARCH 2, 1892:—The 289th. meeting of the Society was held at its rooms, 78 LaSalle street, Wednesday evening, March 2nd, 1892, with over 50 members and visitors present. President Isham Randolph in the chair.

The minutes of the preceding meeting were approved.

The Secretary, reported the following new members elected: John H. Burnham, Joseph A. Watson.

Applications filed: James R. Smedberg, T. N. Conlin, William Shingleton, George Weston, Fred'k H. Davies, James D. Raynolds, Robert E. Orr, Chas N. Roberts, William C. Halliday.

President Randolph stated on behalf of the committee on the "Railway Problem of Chicago" that it was expected that the report would be ready for the April meeting, the absence of one of the members of the committee prevented its completion for the present meeting.

Letters acknowledging the receipt of the vote of thanks moved by the Society for assistance rendered the committee on Bridge Legislation were read from Mr. James Forest, Secretary, Institution of Civil Engineers, London, and Mr. Ernest Pontzen, of Paris.

A letter was read from Mr. O. Chanute, representing the Association of various Engineering Societies in this country, extending to members a cordial invitation to attend the Fifth International Congress for Internal Navigation, to be held at Paris, France, beginning July 21st., 1892, and to continue for ten days. Some excursions, are included, one prior to the Congress to the canals and ports of Northern France, and another after the Congress to the Canals of Central France and to Marseilles.

The letter was accompanied by copies of the various circulars explanatory of the Congress etc., detailing what has been so far accomplished and arranged.

Owing to the work before the Society the President suggested that it would be expedient to postpone further consideration of the matter.

A communication on the proposed Engineering Congress of 1893 was received from Mr. E. L. Corthell, Chairman of Executive Committee, accompanied by circulars.

The Secretary next presented a communication from Mr. Francis W. Parker, on the subject of a School of Technology for Chicago. It had been the subject of consideration by the Board of Directors who decided to place it at once in the hands of the Society:

Gentlemen:—As Chairman of the committee recently appointed by the Chicago Electric Club for that purpose, it is my duty and pleasure to submit to you the following communication:

The members of the Chicago Electric Club have long ardently desired to see the establishment of a high grade, fully equipped, institution of Technology in the city of Chicago. At a recent meeting the subject was fully discussed before them by several gentlemen and it was concluded that the time had arrived when such a project could be safely laid before the people of Chicago by the several engineering societies of the city. The committee of which I have the honor to be Chairman, was appointed to take into consideration the matter and to lay it before the Western Society of Engineers and the Society of Architects of this city. We desire as representing the Electric Club to associate ourselves with similar committees, one from the Architects and the other from your Society the three committees to resolve themselves into some kind of a body which should have for its object the securing of apparatus and equipment for a first-class physical laboratory and museum of mechanical arts. We have thought that in view of the coming of the World's Fair and the general activity in all engineering interests it would not be difficult to secure vast quantities of the material desired for this purpose and practically without expense. We have been encouraged in this belief by the offers of several persons to contribute material aggregating in value a number of thousand dollars. We are disposed to speak very positively for the electrical industries to the effect that they will furnish free of cost substantially everything necessary to equip a physical laboratory so far as such institution may need material and appliances made by manufacturers of electrical

machinery. It is hoped that the interests with which your members are associated would be equally liberal and ready to assist in this laudable enterprise. We have furthermore already secured very encouraging pledges of financial support and we think that the sum of perhaps $250,000 could be raised among the financial men of Chicago for the following purposes: $150,000 for a physical laboratory building; $50,000 for a Museum of Mechanical Arts connected therewith, and $50,000 for additional equipments. In the course of our examination of this subject we have received encouragement to continue from the fact that, when approached, the officers of the University of Chicago received us with great interest. They substantially offered to start immediately a very complete technological institution and to furnish the grounds and all of the expenses, including salaries and the like, if the citizens of Chicago will give to them the buildings above proposed and the apparatus and equipment for such laboratory and museum as above suggested. It appears that they are willing to proceed immediately with the development of their mathematical department and to start the same with an annual expenditure of about ten to eleven thousand dollars.

They have secured $150,000 for a chemical laboratory and propose in like manner to forthwith establish their chemical department and expend theron about $12,000 to $13,000 per annum. They have in the Ogden estate, what it is confidently asserted will not be less than $500,000, the proceeds of which will shortly be placed at their disposal and be available for the purposes of pure science. Now they propose as I understand to establish immediately some or all of the engineering courses; to put at the head thereof a first-class Professor of Physics with a salary of $7000, and to expend on such engineering courses proper about $15,000 to $16,000, per annum to begin with. In addition to this they will of course have all of the usual faculties of a University. In other words the proposition of the University of Chicago is practically to proceed at once with the establishment of a technological institution spending $10,000 to $11,000 per annum on the mathematical department and $12,000 to $13,000 per annum on the chemical department, $15,000 to $16,000 per annum on the engineering courses or a total of $37,000 to $40,000 per annum as a beginning on what is properly technological education, or an absolutely essential part thereof, and to furnish the grounds free if the citizens of Chicago will provide them with the buildings, appliances and apparatus above suggested. If the University will thus spend $40,000 per annum at the start, what will they not do in the future especially in view of their recent new endowment.

We ask you therefore to appoint a committee which committee will be prepared to act with our committee and the committee to be appointed by the Architect's Association, in formulating a plan whereby these three engineering societies may co-operate in securing for this technological institution a suitable equipment for the laboratory, work-shop and museum. When this plan has been perfected we propose with you to lay the matter before certain interested capitalists and philanthropists and present to them both our proposition to furnish the appliances, apparatus and the like and the proposition of the University of Chicago to furnish the instruction and then ask them to furnish the $250,000 above referred to.

It is believed that a proposition so business like and which looks to the establishment of an institution so imperatively needed, will meet with the approval of all of the manufacturing and engineering interests of Chicago and will readily receive the aid of the men before whom the proposition will be laid.

Trusting that this rude outline of the plan proposed, will, so far meet your approval as to lead to your co-operation with us, I have the honor, in behalf of the Electric Club, and as Chairman of its committee, to respectfully invite you to appoint a committee on technological education and kindly notify me of your action in that behalf.

With great regard I am, gentlemen,

Your obedient servant, FRANCIS W. PARKER.

MR. S. G. ARTINGSTALL:—This is so important a matter that I think we cannot at the present time give it due consideration. As stated, it will be right and proper that a committee be appointed to represent this Society, and as I understand there are seven appointed by the Electric Club to communicate with and to meet any committee that this Society may appoint: I move that the President appoint a committee of seven to take

this matter into consideration and report at the next meeting. Motion was seconded and carried.

The President appointed the committee as follows: J. F. Wallace. Sam. C. Stickney, S. S. Greeley. W. S. Bates. Willard A. Smith. L. P. Morehouse, H. L. Bridgman.

MR. GOTTLIEB:—Before I read my paper I would like to ask what action has been taken, concerning the resolution introduced at our December meeting by Mr. Purdy in relation to Iron and Steel in our high buildings.

On a reply being made that the resolution was laid over for future consideration: MR. COOLEY moved that the resolution be adopted. Seconded and carried.

A short paper was then read by the Secretary, on the "KING OF SALT LAKES" by MR. GEORGE W. WAITE, after which MR. GOTTLIEB read the paper entitled: "THE BEHAVIOR OF IRON COLUMNS UNDER HIGH TEMPERATURES."

MR. ARTINGSTALL: remarked upon the value of the paper, but owing to the many experiments and data contained in it, it is practically impossible to follow the reading and to digest it and be able to discuss it intelligently. One thing brought out in the paper he welcomed: the question as to the desirability and availability of cast and wrought iron. He had many times had doubts whether to use cast iron or wrought iron to carry out certain purposes. Not more than perhaps two years ago he had certain work to do for which he used steel for girder purposes. But thought he had possibly made a mistake, and that he had better have used cast iron. Steel was liable to fractures and it was also liable to a good deal of deterioration from not only atmospheric influences, but some other influences which he could not calculate; cast iron would have made greater sections, but it was not altogether a matter of cost. The paper seems to question whether wrought iron or cast iron is better for columns. He repeated that the paper was so loaded with statistics and experiments that it is impossible to follow it up and discuss it intelligently, and that he would like to see it in print and speak on it in the future.

MR. GOTTLIEB: stated that of course he had drawn his own conclusions from the paper, otherwise he would not have tackled it. On the other hand, he did not wish to give his opinion before anybody else was ready to discuss it. He was induced to take this task of translation because we are now in the midst of using metals for architectural purposes more than at any other previous time. In certain quarters there are objections raised to the use of cast iron, because dangerous in the case of fire. Now we are using steel and he did not see nor could he say whether any of these results from testing cast iron columns will not apply to steel columns; they may behave entirely different; they may reel from one towards the other, but he could not say which way. It has, however, demonstrated one fact, that a column protected by a non-conductive substance outside, a quarter of an inch thick, is a safeguard, a good protection for every cast iron column in fire, which is something that ought to be considered and known,—what might be the difference of strength of columns, protected and unprotected; and his last object was, that if a committee should be appointed, which he had no doubt of according to the resolution of Mr. Purdy, to examine this matter, the paper presented might be some help for them, showing what has been done else where.

Adjourned. JOHN W. WESTON, Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. XI. May, 1892. No. 5.

This Association, as a body, is not responsible for the subject matter of any Society or for statements or opinions of any of its members.

"THE RAILWAY PROBLEM OF CHICAGO, IN RELATION TO TERMINALS, RAPID TRANSIT, MARINE COMMERCE AND RELATED INTERESTS."

REPORT OF A COMMITTEE OF THE WESTERN SOCIETY OF ENGINEERS. COMMITTEE: COL. R. B. MASON, BENEZETTE WILLIAMS, GEN'L. SOOY SMITH, E. L. CORTHELL, RICHARD PRICE MORGAN, OLIVER B. GREEN, ISHAM RANDOLPH. H. B. HERR, *vice* COL. MASON, DECEASED.

[Presented May 11th., 1892.]

CHICAGO, JUNE 3rd., 1891.

To the Western Society of Engineers.

Your Committee appointed on the 4th. of June, 1890, to investigate and report upon "The Railway Problem of Chicago in relation to Terminals, Rapid Transit, Marine Commerce and related interests", beg leave to submit the following:

At an early day after their appointment, the Committee in consultation with the President of the Society, reached the conclusion that unless sufficient financial aid could be obtained from the railroad companies whose lines converge in Chicago, and from other parties interested in the subject, it would be impracticable to secure the information necessary to an intelligent consideration of a problem so difficult and complex as that referred to the Committee, and such as the Society contemplated.

In accordance with this plan, application was made to the railroad companies, and subscriptions were obtained, sufficient in amount to

justify the Committee in their opinion in proceeding with their work.

On the 13th. day of September, 1890, the Committee completed its organization by the appointment of Mr. Isham Randolph as Treasurer and Secretary.

Offices were secured, and Mr. E. Philbrick was employed as engineer in charge, on whom was devolved the duty of collecting data of all kinds, and also making such computations and tabulations as the Committee from time to time deemed necessary.

Subscriptions were made to the leading scientific publications and all official documents throughout this country and Europe relating to the subject were sought to be obtained, and those portions of them which contained information useful to the Committee were indexed for ready reference.

After the close of the hot season and return from summer vacation, the Committee met regularly on the first Monday of each month until December when it was decided to meet on the 1st. and 3rd. Mondays of each month.

On the 2nd. of October the following communication was addressed to each member of the Society:

Dear Sir:—

This Committee having entered upon the discharge of the duties outlined for it in the resolution of the Society, desires to avail itself of all feasible means to insure a satisfactory report.

To this end it cordially invites your co-operation, should you have leisure and sufficient interest in the Society and subject to contribute to the fund of information needed.

This Committee would greatly appreciate well considered suggestions respecting any branch of the problem, and if complete plans giving diagrams of strains, sizes, and forms of material, and also estimates of cost are presented, which are accurate and in the judgment of the Committee applicable and feasible, due credit will be given to the author in its report.

Its work is not as individuals, but only as members of the Society, whose welfare in common with yourself it desires to promote, therefore feels at liberty to solicit the aid of each member. Should you oblige the Committee and Society with suggestions or plans and estimates, kindly do so as early as practicable, not later than February 1st. 1891.

Please acknowledge. Yours Truly,

Isham Randolph, Secretary.

Fifty-seven acknowledgments were received, but one member only, Mr. Geo. W. Waite, presented formal suggestions.

At the meeting on the 19th. of January it was determined that it would be very advantageous to make a personal examination of the terminals existing and under construction at Baltimore, Philadelphia

Jersey City, New York and Buffalo, and also en route to visit the St. Clair Tunnel.

Arrangements were accordingly made and on the 19th. of March '91, the Committee accompanied by Mr. L. E. Cooley, President of the Society, and Mr. J. F. Wallace, Vice President, left Chicago via B & O. R. R., in the Santa Fe official car No. 201, placed at their disposal through the courtesy of Mr. Allen Manvel, President.

Col. Henry T. Douglas, Chf. Engr., arranged with Mr. Thomas M. King, 2nd. Vice President of the B & O. R. R. Co. for our transportation to Philadelphia.

The Committee reached Baltimore on the evening of March 20th. The next morning they visited the general offices of the B. & O. R. R., and were received with cordial consideration by the officers of the Company.

After a conference with Mr. Orland Smith, Vice President, an official invitation by Col. Douglas was accepted to accompany him and inspect their harbor terminals and transfer system by steam barges. This inspection gave an admirable idea of the manner of interchange between land and marine transportation on Patapsco Bay.

Also the Belt Railroad, a double track tunnel now in process of construction by the B & O. Co., was visited and examined.

At Philadelpia on the 23rd. and 24th. of March, a very complete examination was made by water and rail of the railway and marine terminals in that city; Mr. Brown, Chf. Engr. and Mr. Joseph T. Richards, of the Pennsylvania Rd. kindly providing us with information and facilities, and they also arranged for our transportation to Jersey City and gave us general plans of the elevated system now being substituted at that terminus of the Pennsylvania Rd. for the surface system.

The great and costly changes made in Philadelphia and Jersey City from surface grades to elevated tracks, securing thereby economy and dispatch in the movement of trains, and avoiding danger to human life, impressed us very deeply as the result of the experience of able and judicious management.

On the 26th. of March a careful and complete examination was made of the railway terminals on New York Bay and the methods of transfer and delivery of freight by barges to New York and Brooklyn. It is worthy of mention, as an illustration of this class of terminal facilities that the Pennsylvania Co., makes freight deliveries at 148 places in those cities and the other companies necessarily delivering in the same manner.

On the 27th. the System of Rapid Transit elevated railways in New York and Brooklyn and also the entrance of the N. Y. C. & N. Y. & H. R. Rds. into New York, through the 4th. Ave. Improvement were examined.

The "4th. Ave. Improvement" is $4\frac{1}{4}$ miles long extending from Harlem River to the Grand Central Depot at 42nd. St. (for details see *Scientific American*, Nov. 14th. 1874).

The construction of this great work is in tunnels, depressed open cuts, and viaducts. The object of it is to secure an entrance to the heart of New York City without crossing any of its streets at grade so as to secure dispatch and economy, and to avoid danger to human life. This was the first very costly railway construction in this country for those purposes, and the expense was borne equally by the railroads and the City of New York.

The facilities for making these examinations, valuable data, and also our transportation via West Shore Rd., to Buffalo, were provided by Mr. J. D. Layng, Gen'l Manager, and Mr. Walter Katte, Chf. Engr. of the Hudson River & W. S. Rd. At New York we were also indebted to Mr. Andrew H. Green.

At Buffalo on the 29th. of March the railway and marine terminals were examined and by the courtesy of Mr. Guthrie, Asst. City Engineer, very valuable information was obtained in respect to the railway problem, in that city, which is quite analagous to that of the city of Chicago, though the conditions are much less stringent.

In Buffalo, by special act of the Legislature, a Commission has been created, composed of 9 members, under whose supervision the proposed plans of relief will be carried into effect.

From Buffalo to Chicago, transportation was kindly provided by Mr. L. J. Sargent, Gen'l Manager of the Grand Trunk, and Mr. W. J. Spicer, Gen'l Manager of the Chicago & Grand Trunk, at the kind suggestion of Mr. Geo. B. Reese, Traffic Manager.

Through the courtesy of Mr. Joseph Hobson, Chf. Engr. the Committee were enabled to make a critical examination of the St. Clair Tunnel; passing through it twice in company with Mr. Hobson.

Having far more than realized the advantages anticipated, the Committee arrived at Chicago on the 31st. of March.

Although all the members of the Committee have had for many years, intimate professional knowledge of the railway and marine terminals and city transit in Chicago and more recently of the proposed elevated rapid transit roads, they have individually and in Committee, carefully re-examined them since their appointment.

Through the courtesy of Mr. O. B. Green, who provided a tug for the purpose, the Committee made a very complete re-examination of the river harbor and its slips; also of the outer harbor and breakwater, constructed by the General Government.

This review of the Chicago harbors having been made immediately after the examinations of the terminals and harbors at the East, as before stated, the Committee found that the information they had so

gathered was very useful in preparing them to consider the conditions at Chicago, as they now exist: having also before them the census statistics of its marvelous growth in commerce and population.

The Committee has further availed itself of the latest scientific publications touching all the questions of construction such as the various forms of tunnels, elevated rapid transit railways and viaducts; also the application of power to each.

Complete plans and estimates of cost, in detail have been considered; including the work done by the Government on the outer harbor of Chicago and similar works elsewhere.

The Committee has not understood that they are expected to submit as a result of their investigations, any plans or estimates in detail as a part of their report, but on the contrary merely to avail themselves of them as of the many other factors that came to their notice on which their general opinions and suggestions are founded.

The subject covered by the resolution appointing this Committee, naturally divides itself into five principal branches.

First, the Harbor: Second, Rapid Transit: Third, Railway Terminals.

Included in the second and third is first elevated and depressed railways: and second application of power and the relation of all the conditions to the main subject, namely the Railway problem of Chicago.

There is no question made that the existing means to perform the work in each branch of the subject as above outlined, are inadequate even to the present demands, and that each and all of them and their relations to each other are, in their operation, too costly and hazardous to human life, and unsatisfactory, and a revision of them is stringently demanded.

It is understood that these matters are to be considered mainly in the commercial relations of Chicago with the country at large and the world; also forecasting the future of the city's local needs.

NATURAL CONDITIONS EXISTING IN CHICAGO COMPARED WITH NEW YORK.

The physical or topographical features of New York are in striking contrast to the natural conditions which obtain in Chicago. New York is built upon a rock-ribbed island, 13¼ miles in length and 2¼ miles in greatest width, averaging 1¼. It lies well above the waters which environ it; waters sufficient in depth to float the largest ocean craft and so land locked as to afford a safe and ample harbor for the vast commerce which has made New York the empire city of the western world.

Her area is fixed and determined by natural barriers and her limit

of growth has been almost reached upon the surface, and the increasing congestion is bringing home to her people, the maxim of ambition, "There is always room at the top," and the time has come when if they are to spread it must be upward. In preparing the surface for streets and buildings there has been a vast outlay made in blasting the trap rock and excavating to secure proper grade lines and one of the problems connected with this work has been how to dispose of the material which had to be displaced. Chicago, on the other hand, has risen from the marshes and although underlaid with rock, it is far below the surface, and is seldom reached by foundations required for buildings of any character: although sometimes where piles of great length are used, their points reach the limestone. Chicago has its great lake and its narrow shallow river and an outer harbor built by the Government, but neither commodious nor safe. The river, while it has been a most important factor in the building of the city, as affording docks, and wharfage, has year by year become an ever increasing disturbance to urban life by reason of the interruption to the intercourse between the three great divisions of the city which its commerce creates. So great is the loss and damage due to this constant interruption, or as it is termed, "bridge nuisance," that the question of whether the continuance of the river traffic, as at present conducted, is not a source of greater loss to the community at large by reason of its interruption to street traffic than can be compensated by the commercial results of the rivers's navigation, is open to debate.

Chicago differs from New York in her area, available for buildings. She has within her corporate limits, 160.57 square miles.

While New York has had to incur considerable expense in getting rid of surplus earth and stone, the problem, with Chicago has been, how to secure material for raising her surface above the line of lake overflow. New York is the great gateway to the world's traffic: Chicago the great inland center of the wealth and influence of the western aggregation of states. When we come to compare the manner of doing business in the two cities, the contrast is even more striking: but two railroads have a right of way entrance into New York, the N. Y. C. & H. R. Ry. and the N. Y. N. H. & H. R. R. and New Haven has a freight line along the Hudson River water-front as far as 59th. street and from there on to 27th. street it occupies 11th. Ave. Its passenger line enters the city at 134th. street, where it crosses Harlem River and from which point of entrance it occupies 4th. Ave. as far as 42nd. street. The freight line is a surface track, the passenger line by viaduct, depressed track and tunnel: crossing none of the streets of the metropolis at grade.

The New York and New Haven R. R. has freight yards at the crossing of the Harlem River north side, but it uses the passenger tracks of

the N. Y. C. & H. R. R. and shares the Grand Central Station with that Company.

Three lines of elevated R. R. traverse the length of the island: the most' extensive from 155th. street to the Battery, about ten miles. There is no daily slaughter of the innocents at the street crossings in New York. Life has been made safe from the swift wheels of the railroads by an immense outlay of money; an outlay borne in fair proportions by the railway and the city, although only one railway enters her streets. she does not suffer in her commerce from that fact, for the opposite shores of her surrounding waters are lined with railroad terminals and from these fleets of barges in tow of powerful tugs bring to her wharfs and warehouses at hundreds of places, the products of the mine, the forest and the field, the loom, the foundry and the rolling mill: labors coarsest results and arts highest triumphs. These deliveries are made with a promptness and system which is most admirable. No grade crossings, and no crowded railroad tracks obstruct the movement. A glance at the map of Chicago, presents a very different condition: the lines of tracks are interwoven most intricately and in several localities, monopolize extensive areas. In Chicago 95 per cent. of the street crossings are at grade and the grade crossings of the roads with each other add immensely to the danger to life and limb, and make the burden of delay to traffic, a costly item in the operating expenditures of the roads. Chicago is crossed from west to east by lines of railway on Kinzie street, 16th. street and 39th. street. It is environed by a belt line within the corporate limits, 21 distinct rights of way converge in lines centering in six great terminals in the heart of the city. One of these terminals affords facilities to six different roads, another to five, two others to three each and another to four.

The C. & N. W. alone of the owners of terminals here accommodates no tenants.

The facts already stated show that the existing railroad conditions in Chicago involve great sacrifice of human life. To change these conditions is simply a question of vast expenditures of money. There are no engineering problems involved requiring originality; all of the forms of construction being well known and in use in other great cities.

MARINE COMMERCE AND RELATED INTERESTS.

A proper consideration of the magnitude and character of the provisions that will ultimately be necessary to handle the Marine Commerce of Chicago and their relation to local traffic and to railway transportation requires that we take up briefly the salient facts affecting these provisions grouped in order under the following heads:

1. The field possible to water carriage of freight through the medium of the great lakes.
2. Facilities for navigation throughout the chain of lakes.
3. The magnitude of lake freight traffic.
4. The character and number of craft employed in this traffic.
5. Cost of water carriage on the lakes.
6. Lake commerce of the port of Chicago.
7. Facilities afforded navigation at the port of Chicago.

POSSIBLE FIELD.

1. As is well known, the field which invites navigation with the ports of the Great Lakes as foci, is not circumscribed by the links of the mighty chain beginning with Michigan and Superior, at Chicago and Duluth, and ending with Ontario at Kingston; but it narrows to the St. Lawrence at the lower end of Lake Ontario and continues down this magnificent River to the Atlantic Ocean, where it broadens to the Boundaries of the world's high seas. Or it may follow the line of the New York canals and the Hudson river to the port of New York, thus joining the Commercial metropolis of the Interior to that of the Atlantic Coast by deep water channels made wholly through home territory.

By one or both of these routes the ports of the fresh water seas of the American continent may be opened to the marine commerce of the world, the Chicago and Duluth become the distributing points for goods brought from the most remote parts of the earth, but most of all they become the seaports for the heavy freight from the interior of the continent seeking a market on the Alantic coast and in the transatlantic.

LAKE NAVIGATION.

2. The facilities for navigation of the great lakes was, in a state of nature, limited. As is well known, it was impossible at Niagara Falls; and greatly obstructed by the rock ledge at the Lime Kilns; at the St. Clair river and flats there was originally but 10½ feet depth of water; it was also impossible at the Sault St. Marie Falls.

By improvement of the natural water ways and the building of canals, transportation is now open from Montreal to Chicago and Duluth. By the deepening of the St. Lawrence river below Montreal that city has been made a seaport for the largest ocean vessels. The U. S. government has deepened the Detroit river at the Lime Kilns to 20 feet and is engaged in deepening the St. Clair flats and river to the same depth; and is building a lock at the Sault St. Marie Falls with 21 feet of water over the miter sill. This improvement being referred to a new reference plane 1.3 feet lower than the old one, thus making the new lock 6.3 feet deeper than the lock through which the present Lake Superior traffic is being carried on, which has a depth referred to the new datum plane of 14.7 feet. When these works are completed the

lakes above the Niagara Falls will be navigable for vessels which can pass through 20 feet depth of water. The Welland canal around Niagara Falls on the Canadian side has 14 feet depth of water and the Canadian government is improving the St. Lawrence river to the same depth by means of locks, and canals, and by deepening the bed of the river. Many projects have been made for securing 20 feet depth to Montreal, and the Atlantic Ocean, for the details of which reference is made to an abstract of a paper by Mr. E. L. Corthell read before this Society, April 8th, 1891, entitled, "An Enlarged Waterway to the Seaboard;" also to a paper entitled the "Radical Enlargement of the Artificial Waterway between the Lakes and the Hudson River," read before the American Society of Civil Engineers by Mr. E. Sweet, State Engineer of New York, in June, 1884.

The interest which this subject has elicited both in Canada and the United States indicates that the time is not far distant, measured by the life of cities, and of nations, when even more than 20 feet to the Atlantic seaboard will be an accomplised fact. Within a year or two, as has been seen, this depth will obtain for all the lakes above the Niagara Falls. And it is not improbable that 21 feet may be had in accordance with a late recommendation of Gen. Poe. He estimates the cost of obtaining 21 feet depth at $3,339,567.96 as against $2,379,058.00 for 20 feet. He urges upon Congress the appropriation for the greater depth because the "end to be gained by its expenditure is so important, and so pressing as to fully justify its appropriation even in one act."

The *Marine Review* of July 16, 1891, says that vessel owners of the lakes, and among them men who have been influential in securing appropriations from the general government for the improvements of inland waterways that have reduced the cost of transportation in a manner amazing to the entire country, are about to lay plans for a 20-foot navigatian in the Erie canal at a cost of probably $150,000,000, and that this great question, so many times discussed on paper, is now for the first time being seriously considered with a view to bringing it before Congress by the men who instigated the building of the St. Mary's Falls, and St. Clair ship canals, and the enlargement of the connecting waterways of the lakes, and have succeeded in showing to the country the wonderful benefits of cheap transportation. It further says that the lake interests have begun to look with favor upon an undertaking that involves the subjecting of costly ships to the delay of slow navigation in lengthy artificial channels. After stating that there is now assured to the chain of lakes 20 feet of water between Chicago, Duluth and Buffalo, it asks of what use would the St. Lawrence canals be as a direct route to the seaboard when Canada does not propose to do more than to increase them to Welland canal size? The Welland

canal has only 14 feet of water and its locks will not admit of a boat larger than 265 feet. To the practical men of the lakes who know that the class of boat required for ocean voyages, or even for the coast trade, must be cut in two in order to go through the Welland canal, this argument is a final one, but the great objection to all routes leading into the Canadian canals below Lake Ontario is that they propose a Canadian outlet for America's greatest inland commerce. It asks whether the State of New York can be induced to turn over to the general government the Erie canal with the understanding that it shall be improved on the grand scale outlined?

Since this was published, the movement alluded to has taken shape in a large and representative convention held at Detroit, December 17, 1891, on which occasion representatives of Lake interests from St. Paul to Oswego assembled in great numbers. The following were among the resolutions passed by this convention:

"Resolved, that this convention does hereby respectfully and earnestly request and urge Congress to authorize the immediate commencement and speedy completion of an unobstructed channel not less than twenty feet in depth and of sufficient width through the lakes and their connecting waters between Chicago, Duluth, Superior and Buffalo, and that the Secretary of War be authorized to make contracts for the entire work, and a sufficient sum of money be appropriated therefor."

Still more significant was the following, as indicating the drift of opinion that a 20 foot waterway must be had through our own territory to the Atlantic seaboard.

"Whereas every consideration of prosperity in time of peace and protection in time of war demands the construction of a waterway of sufficient capacity to allow a free passage of vessels drawing twenty feet of water through our own territory from the great lakes to the Atlantic ocean, therefore:

"*Resolved*, That we request Congress to authorize the Secretary of War to cause to be made surveys, examinations, and estimates of cost of the various practical routes for such waterway, with a view to determine the one which is most advantageous, and that a sufficient sum be appropriated to defray the expense of such surveys and examinations.

Resolved, That this convention strongly favors the improvement of the Hudson river to a navigable depth of twenty feet from Coxsackie to Troy."

Since the adjournment of this convention, other conventions have been held, notably a farmer's convention at Oswego, making similar demands, and the appropriate committee has been active in bringing the subject before Congress.

LAKE CARRYING TRADE.

3. A conception of the magnitude of lake freight carrying trade as it exists to-day will be best gained from Tables I. and II., given in the Appendix to Marine Commerce. Statistics partly taken from the U. S. Census Bulletin. "Freight Traffic of the Great Lakes," issued Jan. 31st, 1891, and partly from other given sources.

The Cargo Tonnage of 107 ports on the Great Lakes for 1889, exclusive of the Canadian coastwise trade, was 27,460,260 tons. 16.41 per cent. of this was the products of agriculture: 52.62 per cent., products of mines and quarries: 0.24 per cent., animal products: 24.97 per cents., lumber: and 5.76 per cent., miscellaneous.

The average distance of carriage was 566 miles, which gives 15,542,507,160 ton miles. The railway ton mileage of the United States for the year ending June 30th, 1889, was 68,727,223,146, which shows that the ton mileage of the lakes is equal to 22.6 per cent. of the total ton mileage of the railways of the United States.

The total traffic of the 107 lake ports, by ports, for 1889, was 51,202,106 tons, of which the tonnage of Chicago was 7,984,038 tons, or 15.59 per cent. of the whole: of Buffalo, 13.14 per cent.: Escanaba, 7.08 per cent.: of Cleveland, 7.07 per cent.: and of Ashtabula, 5.26 per cent. The tonnage for no other lake port equals 5 per cent. of the whole.

The freight tonnage passing through the Sault St. Marie Falls canal during the year ending June 30th, 1890, was 8,288,580, and that for the Detroit river for the season of 1889 was 19,717,860 tons.

Table III. shows the tonnage passing the Sault in 1890 to have been 31 per cent. greater than that passing through the Suez Canal.

The tonnage entrance and clearances of the great seaports of the world for 1889 were: New York, 11,051,236 registered tons: all seaports of the U. S., 26,993,313 registered tons (foreign trade exclusively): Liverpool, 14,175,200 registered tons, of which 4,096,703 tons was coastwise commerce: London, 19,245,417 registered tons of which 7,334,599 tons was coast-wise commerce.

(See Report of the Commissioner of Navigation for 1890, page 336) and (Remarks of Hon. George H. Ely before the Committee of Commerce of the U. S. Senate. Feb., 1890.)

In regard to the tonnage passing through the Detroit river, it should be said that the Marine Review has during the past year frequently stated it at 36,203,586 tons as against 19,717,860 tons given by the U. S. Census. In answer to an inquiry as to how so great a discrepancy is to be reconciled, the Editor refers to a copy of "Remarks of Hon. George H. Ely, before the Committee of Commerce of the U. S. Senate", in which the tonnage is placed at 36,203,586 tons. The Editor says: "The Census Bulletin is not a statement of facts: it is an estimate. Mr. Ely's figures are also estimates, but he has had a

life long, practical connection with lake marine interests. Not so the gentleman who collected the census figures, but they also had to work on estimates, and you will find on examining the statement accompanying the census bulletin referred to, that it contains many paragraphs devoted to an attempt to explain away its inconsistencies as to receipts and shipments. Existing statutes do not permit, as you have undoubtedly found in your search for lake data, of a correct report of the receipts and shipments of any port on the lakes, as there are circumstances under which vessel masters are not required to report to the custom officials when entering or leaving port. The census data was made up from custom house reports, which are not recognized by any one acquainted with the situation. An effort will be made in the next Congress to remedy these defects in the statutes, and untill the remedy is applied, facts regarding lake commere cannot be secured."

An examination of Mr. Ely's estimates convince us that they are much too high. The method pursued by him would be very likely to produce erroneous results. On the other hand, some of the criticisms of the Census Bulletin seem well founded. As will be seen under the head of "Commerce of the Port of Chicago," a very wide discrepancy exists between the Census Bulletin figures, for the port of Chicago, and those prepared from the custom house reports by reliable experts under the direction of Mr. L. E. Cooley. These latter figures we believe to be as reliable as was possible under the circumstances and their variation from the Census is significant.

Our own conviction is that the truth regarding the Detroit river commerce lies between the figures of the Census Bulletin and Mr. Ely's estimate, but much nearer the former than the latter.

FLOATING EQUIPMENT OF THE LAKES.

4. The character and number of craft employed in Lake Commerce may be inferred from the following:

"The number of vessels documented in the various customs districts on the northern lakes at the end of the fiscal year, (see Report of the Commissioner of Navigation for 1890, page 39) was 3,510 and the tonnage was 1,063,064. Of this number 1,272 vessels of 328,656 tons were sailing craft: 1,527 vessels of 652,923 tons were steamers: and the residue consisting of 711 vessels reported of 81,485 tons, were canal boats, barges, etc."

In table IV of Appendix is given the classification of the vessels, as to size, composing the steam and sailing tonnage of the lake, June 30th, 1890. It is stated that in this schedule there are more steam boats of 1,000 to 2,500 tons capacity than in the combined ownership of this class of vessels in all other sections of the country.

In Table V is a very instructive exhibit of the changes in the float-

ing equipment on the Lakes since 1886. The value of the vessels therein tabulated was $30,597,450 in 1886, and $58,128,500 in 1890, an increase of 90 per cent.

An examination of the table shows that sailing vessels are giving place to steam vessels. The former having increased largely, both in number and in tonnage, while the latter have decreased in both respects.

Steam vessels are of a constantly increasing size, and the number of the large ones is rapidly increasing. Steamers of more than 1,500 tons have increased 423.8 per cent. in number and 440.3 per cent. in tonnage.

Steel is becoming more and more the material of construction, wood and iron barely holding their own. Composite construction has increased largely though still not holding an important place.

In Table VI is a record of the boats built in Lake ship yards since 1886. It shows that in five years 244 vessels have been built with a gross tonnage of 477,925, and an average of 1,950 gross tons, having a valuation of $32,726,000.

Of the 1890-91 boats, 21 are of steel, and all but four steamers. They generally range from 2,000 to 3,250 gross tons though there are a few small ones of only a few hundred tons.

The Canadian lake tonnage is given by "Inland Lloyd's" (Canadian Hulls) at 647 vessels with a tonnage of 132,961 tons, estimated value $3,989,130. (See Report of Commissioner of Navigation, page 361.)

Table VII gives the tonnage of vessels built on the lakes for each year from 1857 to 1890 inclusive. It is instructive as showing the rapid increase, beginning with 1887.

Table VIII gives the total documented shipping of the United States and of the United Kingdom, June 30th, 1890.

It shows that the tonnage on the Northern lakes exceeds that of the U. S. engaged in foreign trade, and that it is slightly more than one half of all the coastwise shipping in the U. S.

The following items taken from the Marine Review for 1890-91 are instructive as giving an idea of some of the best vessels on the lakes, and what they are capable of doing.

Some of the largest and fastest lake vessels are the following: Owego and Chemung belonging to the Union Steam Ship Co., said a year or two ago to be the largest on the lakes, being 350 feet over all. Time of the Owego, Buffalo to Chicago, 889 miles, 54 hours and 6 minutes, or 16.4 miles an hour.

The Maryland—Inter-Ocean Transportation Company—335 feet, 42 feet beam, 24 feet depth of hold, carries ore from Escanaba to South Chicago, largest load carried 3,322 tons gross, or 3,737 net tons, with 16 feet 2 inches draught. She carried from Escanaba to South Chica-

go 29 ore cargoes, aggregating 95,000 gross tons, an average of 3,-275.8 gross tons which is not much less than the maximum load given above.

The E. C. Pope steel steamer put into service early in May, 1891, built on the same model as the Maryland, 337 feet over all, 42 feet beam, 24 feet hold, with the same depth of water will carry 75 to 100 tons more than the Maryland. It has carried from Ashland to Lake Erie Ports 2,718 gross, or 3,074 net tons, light draught to pass the Sault Lock, depth of water 14 feet 3 inches. On 16 feet 2 inches draught will carry 3,850 net tons, and on 19 feet draught will carry 4,800 tons.

Other iron ore carriers give records as follows: Brazil, 2,932 gross tons or 3,285 net, from Escanaba; Corsica, Mutual Transportation Company of Cleveland, 2,920 gross or 3,271 net tons from Escanaba.

Steam ship Pontiac (steel) in 1890 carried 31 loads from Marquette and Escanaba, 15 from Escanaba to Lake Erie ports, aggregated 41,-907 gross tons, average of 2,794. Carried the largest cargo ever brought through river Sault St. Marie, viz: 2,933 gross tons and has the distinction of having discharged ore twice in the same week, a total of 5,525 gross tons, at Cleveland.

The following is the record of some grain carriers: The W. H. Gilcher of Cleveland, 114,982 bushels of corn, Chicago to Buffalo. Steel boats, American, Drake syndicate, 111,507 bushels of corn, Chicago to Buffalo: Emily P. Weed, Holliston Transportation Company, 111,000 bushels of corn, Chicago to Buffalo. Wooden boat, Neshoto, K. R. Rhodes of Cleveland, 102,000 bushels of corn from Chicago. E. C. Pope, 125,730 bushels of corn, Chicago to Buffalo.

Western Reserve, 96,258 bushels of wheat from Duluth, and 52,-900 bushels of wheat and 56,250 bushels of corn from Chicago, the equivalent of 112,923 bushels of corn. Draught 15 feet 1 inch.

Speed. Owego, Union line of Buffalo, Buffalo to Chicago, 889 miles, 54 hours, 16 minutes, 16.4 miles an hour: Saranac, Lehigh Valley line, Buffalo to Lime Kilns, 240 miles, 15 hours and 10 minutes, 16 miles per hour.

From the official report of Gen. O. M. Poe, dated May 14, 1891:

"As evidence of the remarkable speed attained by many of the new and large freight steamers, is the case of the Manola, owned by the Minnesota Iron Co., wdich reported to the Sault St. Marie canal an aggregate of 49,201 miles run during the season of 1890, on voyages which included the canal, carrying of 77,124 tons of iron ore through the canal. This vessel made one trip to Escanaba, which, added to the preceding, gives 50,580 miles in 223 days, or an average of 9.6 miles per hour for every hour of the season. Probably the greatest distance

ever run by one steamer in the same length of time. Her average time in port on each round trip was 19½ hours."

"There were eleven steamers reported at the Sault St. Marie, which made aggregate runs of between 30,000 and 40,000 miles each during the season 1890, and one of these ran over 40,000."

It is stated that the aggregate voyages of several steamers running between Chicago and Buffalo, and not reported at the Sault Lock amounted to more than 40,000 miles each, and that two of them, the Hudson and the Harlem, made over 49,000 miles each. These statistics show the capacity of the lake steamers is being increased in the direction of speed as largely as in other ways.

FREIGHT RATES.

5. Mr. Chas. Keep, Secretary of the Lake Carriers' Association, estimates the value of cargoes carried on the lakes in 1890, at $305,000,000.

Satisfactory information regarding the cost of carrying these immensely valuable cargoes that not only gives the present rate per ton for different commodities, but past rates, so as to enable an intelligent study of the changes that have taken place in the cost of carriage is difficult of access. By considerable researches the fragmentary facts have been gleaned. Table IX., giving the freight rates on wheat from Chicago to Buffalo and to New York, has the widest scope of anything attainable and affords the best opportunity for generalization. Wheat being a staple article of commerce, it furnishes a fair criterion of freight rates in general. The table has been compiled from the sources given, and, it is believed, represents the facts closely. That it is not strictly accurate in every respect is known from the fact that when data from the different sources named lapped one over the other, they did not always correspond, though not differing materially. In such cases the figures that seemed the most probable were used. They are sufficiently accurate for the purposes of this discussion.

This table shows a steady decrease in both rail and water rates from 1865, at the termination of the war, to about 1880, since which time they have been only marked by minor fluctuations. For the last ten years the average rate on wheat per ton mile from Chicago to Buffalo has been 1.1 mills, and by lakes and Erie canal from Chicago to New York 5.0 mills per ton mile.

Though there has been but little permanent change in the rates on wheat for ten years past, this is not true of freight rates generally.

During the years 1889-90 the average rate per ton mile on freights generally via Lakes from Chicago to Buffalo was .93 mill and during the year 1890 it was .76 mill or only about 15 per cent. of the rail rate per ton mile, viz: 4.9 mills.

The freight rates on all articles of commerce passing through the Sault St. Marie canal for 1886 to 1890 inclusive, reported officially to Gen. O. M. Poe, is given in table X.

It shows that the average rate for each year respectively, is as follows: 1887, 2.3 mills per ton mile: 1888, 1.5 mills: 1889, 1.5 mills, and 1890, 1.3 mills per ton mile.

During 1890, several steamers carrying iron ore from Escanaba to Lake Erie ports, made 32 to 36 round trips of 1,178 miles each, and 55 cents per gross ton, or slightly over 9/10 of a mill per ton mile. The average rates from Escanaba to Lake Erie ports was $0.887 per gross ton or about 1.5 mills per ton mile.

For 1891, the *Marine Review* of May 21, gives the lake rates as follows:

Iron ore from Lake Superior ports to Erie ports, 90 cents; and from Escanaba to Erie ports generally 65 cents, though some vessels have been chartered at 60 cents.

Grain from Duluth to Buffalo, 1¼ cents per bushel.

Coal from Erie ports are strong at 60 cents to Milwaukee, 50 cents to the head of Lake Superior, 45 cents to Escanaba.

For iron ore these rates represent about 1 mill to 1.2 mills per ton mile and for coal from ½ mill to 8/10 mill per ton mile.

The rates on iron ore are per gross tons. If reduced to net tons the price per ton mile would be less than 1 mill.

Grain at 1¼ of a cent per bushel from Duluth to Buffalo is at the rate of about 4/10 of a mill per ton mile.

This same paper, Feb. 18, 1892, gives the average contract rates on iron ore for 1891, from Escanaba $0.65: Marquette, $0.90: Ashland, $1.00. The average contract rate for twenty years was, from Escanaba, $1.205: Marquette, $1.70; and Ashland, $1.31: average for seven years. The expense of handling, always borne by the vessel, is 21 cents per ton.

By the calculations of Mr. Chas. H. Keep, Secretary of the Lake Carriers' Association, the total freight charges on the lakes for 1890 amounted to $23,000,000 and the total ton miles was about 15,500,000,000; this gives an average rate per ton mile of 1.45 mills. As has been seen by Gen. Poe's report, the average rate of the freight passing through the Sault in 1890 was 1.3 mills.

According to statistics prepared by Captain James Stone of Cleveland, the average rates on soft coal from Ohio ports to the ports named for seven years, 1885 to 1891 inclusive, and the rates for 1891, are as follows: Chicago, $0.77 and $0.58; Milwaukee, $0.74 and $0.61; Escanaba, $0.55 and $0.52: Duluth, $0.62 and $0.49 per net ton; and on hard coal from Buffalo to Chicago, average $0.74, 1891, $0.56: Buffalo to Duluth, average $0.52, and 1891, $0.29 per net ton. On hard coal this

is an average of 0.083 mill and 0.063 mill per ton mile to Chicago, and 0.052 mill and 0.029 mill per ton mile to Duluth.

From a statement made by Mr. S. A. Thompson of Duluth, before a Board of U. S. Engineers recently held at Albany to consider the deepening and widening of the Hudson river, the following items have been taken. See Marine Review, April 16th, 1891.

Poor's Manual gives the average railroad rate per ton mile in 1882 as 12.36 mills, and for 1889, 9.76 mills. Careful experiments by the Grand Trunk railroad show the actual cost of hauling freight by rail to be 5 mills per ton mile. The average cost of all the railroads reporting to the Interstate Commerce Commission for the year ending June 30th, 1890, was 5.93 mills. The lowest cost on record is made by the Lake Shore & Michigan Southern railroad, which in favorable years reports the cost at 4 mills per ton mile.

By lake wheat has been carried from Chicago to Buffalo for one cent per bushel or $^4/_{10}$ mill per ton mile, and thousands of tons of coal have been carried from Buffalo to Duluth at 25 cents per ton or $\frac{1}{4}$ of a mill per ton mile. Mr. J. J. Hill, president of the Great Northern Railroad Co., is quoted as authority for the statement that with their line of steamers of 2,700 tons capacity on present depth of water at the Sault, running from Duluth to Buffalo, the trip is made in $3\frac{1}{2}$ days, a distance of 1,000 miles, at an actual expense of $120.00 per day, which makes the actual cost of carrying freight from Duluth to Buffalo 0.15 mill per ton mile, which is only one twenty-sixth of the cost by the Lake Shore & Michigan Southern railway, which, as has been seen, makes the lowest record.

From the facts given, we see that freight rates on the lakes are growing less year by year: that a considerable amount of business is done for less than $\frac{1}{2}$ mill per ton mile, and the greater amount for about 1 mill, while the average for all kinds of articles is under $1\frac{1}{2}$ mills per ton mile.

It is fair to conclude, that in a few years, if the late improvement in the lake fleet continues, the average rate of the freight on the lakes will not exceed one mill, and that a large portion if not all of the long haul business will be done for $\frac{1}{2}$ mill per ton mile, or at ocean rates. It seems probable that the only thing which may stand in the way of such a consummation will be inadequate harbor facilities which prevent the carrying of full cargoes, and causes unnecessary loss of time in port.

As to the statements made by Mr. Thompson regarding the actual cost of carrying freight by rail, it should be said that there are a very few roads (eight in all) reporting to the Interstate Commerce Commission, that show a lower cost than 4.0 mills per ton mile, notably the Chicago, Burlington and Northern, that reports 2.9 mills per ton mile.

Four of these eight roads range from 2.6 to 3.6 per ton mile, all the others, with exception noted, are short coal roads. The average cost for 1889 for all the roads of the country given by the Interstate Commerce Commission was 5.93 mills per ton mile, the rates charged being 9.32 mills per ton mile.

COMMERCE OF THE PORT OF CHICAGO.

6. The commerce of the Port of Chicago, including South Chicago, is given by the United States Census for 1889 at 7,984,038 tons or 15.59 per cent. of the total commerce of the lakes, taken port by port, 5,069,973 tons being receipts and 2,914,065 tons shipments. The classification, and the per centage which the tonnage of each commodity sustains to the total tonnage of that commodity, is given in Table XI.

The commerce of the port of Chicago for 1889, as compiled from the Board of Trade and custom house reports, (See Lake and Gulf Water Way, app. 6 and 7, by L. E. Cooley) is 8,325,047 tons, and of South Chicago, 787,471 tons, a total of 10,112,528 tons, which is 2,128,490 tons more than the amount given by the U. S. Census. This is a material discrepancy, but a comparison of the detail figures show that in the item of lumber 1,655,448 more tons are shown to have been received than the Census gives, and under head of general merchandise, 384,240 tons more than given by the Census. There are also discrepancies of smaller amounts in a large number of other commodities, which accounts for the whole difference.

The discrepancy lying, as it does, almost wholly in receipts, and mainly in the one item of lumber, is calculated to make one distrustful of the census in this regard. There is a large amount of lumber received, which is picked up around the lakes, that would not be recorded at any place other than the port of Chicago.

Table XII gives the tonnage of the commerce of the port of Chicago for 30 years, 1858 to 1890 inclusive, omitting 1859, 1860 and 1861, which are not obtainable. The table has been prepared from one given in the report of Ricard O'S. Burke, Engineer in charge of Harbors, published in the Report of the Department of Public Works for 1890. It was compiled from the Board of Trade reports, and represents the rated tonnage of the vessels, and not the actual tons of freight carried. It shows the growth in the average tonnage of vessels, and decrease of their number.

From this it is seen that the number of arrivals and clearances for 1865 were a little greater than for 1890, but the tonnage had increased about two and one-half times: the average tonnage of the vessels used having increased in the same ratio.

As shown by the Chicago Board of trade reports, during seven

months of navigation from May 9th to Nov. 28th, 1891, the total shipment of all kinds of east bound freight from Chicago was 4,265,934 tons; of this the lakes carried 2,705,084 tons, and nine leading railways 1,560,850 tons, that is, 63.4 per cent. of all east bound shipments went by water. In addition to this, 150,000 tons of grain was loaded into vessels during the winter of 1890-91 and taken out on the opening of navigation.

FACILITIES FOR NAVIGATION AT THE PORT OF CHICAGO.

7. The facilities afforded Marine. Commerce at Chicago will be appreciated from the following facts:

The Chicago harbor in all its ramifications is 20.7 miles in length and has 37.6 miles of dockage, not including street ends.

The purposes for which this dockage is used can be seen from Table XIII, taken from "The Lakes and Gulf Waterway" by L. E. Cooley.

The Calumet harbor is about six miles in length, including slips, and has about the same length of dockage. It has been developed for 16 feet of water and a width of 200 feet. As yet the few improvements along this harbor do not stand in the way of its enlargment to almost any size.

The Chicago harbor proper is different in that it is narrow and is flanked by high massive buildings in the heart of the city, and is spanned by 48 drawbridges which have become so great an impediment to navigation that vessel movement through it is difficult and tedious. Its improvement has been carried out ostensibly to secure 15 feet at low water, though this depth has never been practically attained. Fourteen feet draught being the limit which can reach the coal and iron docks in the city.

At low water there is a depth of about 17 feet over the La Salle street river tunnel, and since the lowering of its roof, the same over the Washington street tunnel. The new tunnel being built by the West Division Street Railway Co. under the South Branch between Jackson and Van Buren streets will have a depth above it of 18 feet.

Actually at low water, the Chicago harbor, within the limits in which the greater part of the shipping is done, will not admit vessels drawing over 14 feet. Owing to the river tunnels, the natural tortuousness of the stream and the haphazard manner in which the dock-lines have been established—or been allowed to establish themselves—and the encroachments which the necessities of street travel have made in the way of bridge piers and abutments heretofore noted, the present harbor seems incapable of that growth which the necessities of lake commerce demand.

That some remedy for this state of affairs is imperatively demanded is admitted on all hands. The trip up the South Branch on the steamer Saranac made on the 16th of June by some of the mem-

bers of your committee, on invitation of the Vessel Owner's Association, was calculated to impress this statement. On this occasion many prominent gentlemen connected with the press, and other influential citizens received an object lesson in river navigation, which, judging by the tone of the press editorials, has not entirely failed of its purpose. At any rate there would appear to be no one to dispute the proposition that something must be done to increase the harbor facilities of the port of Chicago. The only point of difference being, what shall it be.

By the statistics hereinbefore given, the port of Chicago is shown to transact 15.59 per cent. of the total commerce on the Great Lakes, being the largest inland port of entry in the United States. The number of arrivals and clearances for 1889 were 21,788, with a registered tonnage of 10,267,831, the net amount of freight handled for 1889 as shown by the U. S. Census being 7,984,038 tons, and by compilations from Custom House and Board of Trade reports, 10,112,528 tons. The magnitude of this will be appreciated when it is remembered that the entrances and clearances (Registered), in foreign commerce, of all the seaports of the U. S. for 1889 was 26,383,313 tons; of New York, 11,051,-236 tons; of Liverpool, 14,175,200 tons, including coastwise commerce: and of London, 13,245,417 tons, including coastwise commerce. That is, the tonnage of the port of Chicago is not quite ten per cent. less than the foreign commerce of New York; it is 53 per cent. of the total shipping of London: 72 per cent of Liverpool, and about 40 per cent. of the foreign tonnage of all the seaports of the U. S.

If the average "Haul" on the commerce transacted by the port of Chicago is the same as for the total lake tonnage, viz: 566 miles, then the total ton mileage of the registered tonnage of this port in 1889 was 5,811,592,346, which is 8.46 per cent. of the total railway ton mileage of the United States. During the seven months that navigation was open in 1891, as has been seen, about two-thirds of all the east bound freight was carried by water.

The facts are conclusive in establishing the importance of the lake commerce of Chicago and present the most cogent reasons why this artery of the city's life should not be allowed to stagnate but should be enlivened in every possible way.

We have seen the magnitude of the business transacted by water and the inadequacy of the harbor facilities furnished. We have seen how the number of vessels entering at this port is decreasing, while the total tonnage and the carrying capacity of lake vessels is increasing at a rapid rate. The 206 boats built for lake business in five years ending in 1891, had an average tonnage of 1950, and at least one vessel in service has a net capacity of 3,850 tons, while a great number carry from 2,500 to 3,500 tons. With harbors and channels 20 feet in depth a num-

ber of vessels would carry over 5,000 tons, and a still greater number would carry over 4,000 tons, an increase of more than 50 per cent. in their capacity. We have seen how the general government is encouraging the building of still larger boats by furnishing 20 to 21 feet depth of water in all the narrow and shallow passages throughout the lakes: this means upwards of 18 feet draught for these large vessels if harbor facilities could be had. The cheapening of the cost of transportation is following in the wake of deep draught vessels, and freight rates by water are but a small fraction of railroad rates for similiar service.

Nothing in the history of water transportation is more clearly settled than that cheapening of the rates of carriage follows the deepening of the public waterways, even in a greater ratio than the direct increase of draught. An increase in the draught of vessels of given size means a tonnage increasing more clearly as the square of the relative depths, than in the direct ratio: and an increase of tonnage inevitably brings decrease in cost of transportation.

If this city is to continue to lead in the commerce of the Great Lakes then its marine terminal facilities must be improved. An inadequacy in some harbors will not stand in the way of large vessels plying between those harbors that do furnish these accommodations. If Buffalo and Duluth will harbor vessels drawing 18 to 20 feet, while Chicago will not, then cheaper rates will ultimately prevail between the two first mentioned cities, than between either of them and Chicago. Already, as has been seen, lower rates both for wheat and coal obtain between Buffalo and Duluth than between Buffalo and Chicago, nothwithstanding 111 miles greater distance and the Sault St. Marie lock.

Chicago then must take up the matter of an improved harbor or suffer serious injury to her commercial interests. But in attempting such improvements, care must be had that some other incubus on its prosperity does not become more firmly established. Improved harbor facilities must not become the pretext for riveting other chains which will hamper its growth.

There are four ways in which the desired harbor improvement can be had, so far as the more accommodation of vessels is concerned.

1. The Chicago river can be deepened and widened to any desired extent, and the present bridges replaced with more commodious ones, or the streets carried under the river with tunnels.

2. A harbor can be created on the lake front and docks and piers built so as to accommodate all the shipping of the port, or such part of it as is not transferred to the Calumet, or done by lighters in the Chicago river.

3. The Calumet river and lakes can be improved and other interior

channels made in the low lying Calumet region and the shipping of the port done at that point.

4. Other entrances can be made to the North and South branches of the Chicago river, and the entrance through the main river abandoned by lake craft, and all kinds of vessels that cannot pass under bridges.

Let us consider these propositions in their order, and as far as possible trace the ultimate consequence of adopting one or the other.

IMPROVEMENT OF PRESENT HARBOR.

If the first proposition be adopted as the policy of the city, then the Chicago river and its branches must be deepened to at last 20 feet below datum, but more likely in the course of years to 22 or 24 feet; it must also be widened and straightened in a number of places, and many of the bridges removed to make place for more commodious ones, or their places must be taken by river tunnels. No improvement of this character can be deemed adequate which will not allow the free passage of vessels of 400 feet length and 20 feet draught. This will involve the reconstruction of all the river tunnels and of many of the tall buildings on the river bank, and also of all or nearly all of the bridges. If new bridges be built, then a large amount of the most valuable land along the docks must be taken, and the present structures destroyed to furnish swinging room for the bridges; unless indeed, some form of bridge be adopted which will be operated wholly within the width of the streets.

The use of movable bridges however from 12th street north to Chicago Avenue, and from the junction of the two branches to Rush street, is not to be counted a permanent thing for a city fast growing into millions of inhabitants. It would seem to your Committee that it is useless to expect rapid transit, or even to aspire to ordinary facility of street movement, through streets hampered as are the down town Chicago streets, with movable bridges. We believe that such bridges must be done away with, and that one of the most important and difficult problems facing the city is the finding of ways to accomplish this end. The process of congesting the south side business center can not go on indefinitely without adequate access thereto be furnished. This district is fast filling up with 12 to 16 story buildings, thus supplying greater accommodations for business, and concentrating more people than are to be found within an equal space anywhere else in the world. There is probably not another waterway in the world that is navigable for marine commerce that passes through property of such value as does the Chicago river throughout the length specified, and probably no other one that so many people cross and recross to business.

If bridges should be discarded and tunnels adopted for the central district of the city the top of the tunnels would have to be placed not less than 22 feet, and their grades under the river not less than 40 feet, below datum; the street grades being 14 feet above datum, would necesitate a rise of 54 feet from the tunnel under the river to the street grades. At the rate of 4 in 100 it would require inclined approaches 1350 feet long, which would reach to Washington street south of the main river and to Indiana street north of the same: and on Washington street would extend to 5th Avenue, and on Jackson to La Salle, and would reach beyond Jefferson street on the West Side.

It would give a total length of approaches and tunnel combined of considerably more than half a mile. The mere statement of such a proposition is to rule it out as wholly impracticable from every point of view. Such tunnels would mean a rebuilding of a large part of the city, and the river would become a more effective barrier between its different sides than now.

There is then in the opinion of your committee a necessity of adopting some plan by which the city of Chicago can dispense with its harbor entrance through its business center. It can not be maintained as at present without jeopardizing, if not seriously injuring, the city's future interests.

LAKE FRONT.

The second proposition, to create a harbor on the lake front as an exclusive or main reliance, is open to at least our serious objections.

One is the enormous cost. There is not enough space available on the lake front to furnish room for the shipping of the port, and sites for warehouses, elevators, lumber and coal yards, and the large number of manufactories which need dock facilities. By reference to table XIII, it is seen that there are 252 lumber, coal and stone yards in the city, occupying 17.9 miles of dockage: 55 elevators and warehouses occupying 3.7 miles; 54 manufactories of various kinds occupying 4.7 miles; and a large number of miscellaneous industries occupying a few miles more of dockage. If it be granted that there are a number of these industries which are not wholly dependent upon water connections, still there are enough that do need such facilities, to swell the amount of dockage required far beyond the possibilities of the space available.

It must be borne in mind that for a lake front harbor to be a substitute for the river harbor, it must not only furnish facilities for the loading and unloading of marine commerce, but it must also furnish cheap sites for industries, which, though not wholly dependent upon water transportation, are yet benefitted by having it at hand.

The improvement being made by the Lincoln Park Commissioners, or by the property owners under their direction, shuts out all shipping

north of the north pier of the harbor entrance, except the little which has already gained a footing there, and if it be granted that it could extend to 39th street south of the river, this would give barely 4½ miles of lake front. With the best system of piers and slips that could be provided, this would not furnish sufficient room for the present and prospective needs of the city without extending far out into deep water, or without building an inclosed harbor with piers and docks skirting it on both sides. This latter plan would render bridges necessary from one side of the harbor to the other, and the expense involved in such an undertaking would be enormous.

Another objection is that a lake front harbor as an exclusive reliance involves the complete closing of the present harbor to all lake going crafts, allowing only canal boats, scows, lighters, and such boats as can pass under fixed bridges, access thereto. The effect that this would have upon vested interests, and upon the value of dock property, and of appliances used for handling marine commerce in the way of elevators, etc., would be ruinous. Lighters cannot be used; lake freight rates will not stand the increase which even the most perfect system of lighterage would render necessary. The cheapest system of lighterage that can be devised will be likely to increase the rates between Chicago and Buffalo at least 50 per cent., and as has already been seen, freight rates are now materially less between Buffalo and Duluth than between Buffalo and Chicago.

Still another objection is that to join railway and water transportation on the lake front, and to distribute local freight from this point, renders it necessary that all freight that comes from, or goes into the interior, shall be hauled in cars across the city, and that local freight shall be trucked through streets already congested beyond endurance, thus aggravating many fold the evil of railway freight traffic. One ship load of 2,000 tons represents 100 car loads, and 500 truck loads. One vessel passing through bridges is far more tolerable than 500 truck loads hauled along the streets.

Whatever is done to improve the terminal facilities for both rail and water borne commerce should be with an eye to simplifying its transfer and distribution, and not to render it more unwieldy and difficult. Without reference to cost, such a requirement alone would be fatal to a lake front harbor.

A fourth and last objection is to a certain extent an esthetic one. The matter of preserving the lake front so that it shall not be shut off from the central part of town by warehouses, manufacteries, and the numerous industr es which a lake front harbor would engender, is important. With such a harbor, instead of pure air from the lake, there would be smoke and dirt.

Taking it all in all, such a plan would involve an enormous first

cost without compensating advantages, and a destruction of property values caused by closing the Chicago river to lake craft, which would be incalculable; it would contribute to render business in the city more and more difficult to transact, and would cut the city off from a lake view and pure lake air. We therefore do not consider that a plan for a lake front for general freighting should be seriously entertained.

CALUMET HARBOR.

The third proposition to improve the Calumet river and lake, and to develope the low districts adjacent, so as to accommodate the shipping of this port, is open to many objections. That policy can only work evil in the long run, which stimulates the growth of population across the Indiana line, to which those industries that wish to escape legitimate taxation, and those whose bills of health are not clear, can withdraw beyond the reach of the taxgatherer and the state legislature, there to spew their filth into the lake without let or hindrance.

Only about ten per cent. of the business of the port of Chicago is transacted in the Calumet, and this is mostly due to iron ore which is received by the Illinois Steel Works, which indicates that that harbor is too far to one end of the city to become a fit distributing point. Sixty-six per cent of the lumber and seventy-five per cent. of the coal brought to Chicago by lake is used in the city, and a large amount of other articles of commerce is used here also. Such business can be done economically at no other place than near to the consumer, which is where the population exists. It should be remembered that the commerce of the city is the city.

That the commerce of the Calumet harbor will increase in a natural and healthy way seems inevitable, and it is to the interests of the city as a whole that it should, but it can never be made a substitute for the Chicago harbor, notwithstanding the fact that there is little as yet to interfere with its developement to any required depth or width.

NEW HARBOR ENTRANCES.

The fourth proposition is that entrances be made to the North and South branches of the Chicago river and the present entrance closed to vessels. It is readily seen how essential it is to the continued growth of Chicago and the transaction of the business of several millions of people, which the city will surely have in a comparatively short time, that access to the business center on the South side should be had from the North and West sides without running the gauntlet of movable bridges. It is also easy to see that such bridges are an evil for which a remedy must be found. The concentration of so many people and so much business, in so small a space as is now taking place, means the streets thronged with people and vehicles. These throngs need opportunity for uninterrupted movement not only from one side of the river to another,

but from one part of the business center to another. Such opportunity does not exist. largely owing to the continual opening and closing of the bridges across the river. The opening of a bridge does not merely stop those who are seeking to cross that particular bridge, but it stops others who are traveling on the same street and on intersecting streets with no intention of crossing the river. Thus the stoppage of one person or team may be the occasion of the detention of several others, and one evil is often multiplied several fold. The time is not far distant when there will be double the number of people spending the business hours of the day, and double the amount of business done in the district bounded by Van Buren street and the river, and by Michigan Avenue and the South branch, that there is today. When that time comes, if the movable bridges are still in use, street travel will become next to impossible, and even with fixed bridges the utmost care will need to be exercised to keep street traffic open. We are convinced that any wise solution of the harbor problem must have for its ultimate end the closing of the bridges in the central part of town.

But, it may be asked, how is this to be done in the face of the immense commercial interest dependent upon the Chicago harbor. The answer to this is found in the fourth proposition, viz : open two new channels from the lake, one to the North branch, and one to the south fork of the South branch.

If it is urged that to build channels more remote from the center of the city will be but to transfer the evil of movable bridges to other points where it will become of equal magnitude to the existing one, the answer that cannot be too often reiterated is, that the greatest evil is not a few moments or minutes delay to the individual, but it is the multiplication of this evil many times by the general obstruction of street travel. Any one who has observed crowded streets knows how great a derangement it is to have travel stopped even for an instant. There are people and teams who cross and recross the existing bridges many times a day.

With other entrances provided, the number of times people and teams would cross movable bridges would be enormously reduced. With bridges over the main river closed from Rush street to Franklin, and those over the North branch to Chicago Avenue, and over the South branch to 12th street, the whole of the population of the West Division of the city would have uninterrupted access to the business center of town ; also all of the population of the North side south of North branch harbor entrance, and all that of the South side north of the South branch harbor entrance. Taking the population distributed to-day as shown on a population map prepared for the Chicago Sanitary district, there would be, under the worst possi-

ble location for such entrance, only 15 per cent. of the people who would need to cross a movable bridge to reach the business center, and only six per cent. with certain possible locations that can be made. Now, about 70 per cent. has to do so. But such figures do not give an adequate idea of the reduction in the number of crossings of movable bridges which would result. As it now is, there are thousands of crossings of the down town bridges occasioned by business intercourse during the day. There are thousands of teams and persons each crossing back and forth many times a day, on business errands. So that it is impossible to estimate the lessening of the bridge evil which will occur from the change in harbor entrances as proposed.

Again, the population in the Calumet region is essentially a local one. It is a manufacturing population, very few of whom have occasion to visit the business center regularly. When these things are considered, it is safe to say that the actual crossings of movable bridges would be less than 10 per cent. of what they now are, if possible changes in the harbor entrances were made; and the evils arising therefrom, including the general interruption to street travel in the business center, would be immeasurably reduced.

Any bridge nuisance which is likely to be brought into being is preferable to that which is in existence, and no method of harbor improvement which perpetuates the present regimen should, in our opinion, receive serious consideration.

On the other hand, as has already been pointed out, no method which involves the absolute closing of the Chicago harbor is feasible. These two propositions may be said to be the determining factors of the problem. *The harbor cannot be closed but the bridges must be.*

There seems then only one alternative, a harbor entrance to the South Branch and one to the North Branch. The proper locations for these entrances are matters of detail into which this committee cannot undertake to enter, except to submit the opinion that these open channels shall be located as far as practicable, so as to interfere the least with existing conditions of population, rapid transit and railway entrances to the heart of the city.

It has frequently been suggested that the bridge evil can be done away with by a resort to tunnels under the river, but as has heretofore been pointed out, this project, though wholly impracticable in the center of the city where the approaches would extend a quarter of a mile from the river into business property which is worth from $5,000 to $10,000 a front foot, is not impracticable many miles from the center of business where the property is used for residences. It is entirely feasible to provide tunnel passages for streets in such a case without permanent damage to the neighborhood; and to provide that all the main lines of railroads cross in like manner.

But it will be asked, how is this to be accomplished? Where are the many millions of dollars to come from which will be required to carry out such a work? To one who realizes the importance of the work and the immense resources of this city and the U. S. government, which could be made available, the most difficult part of the problem is not, how to raise the funds; not how the work is to be executed in an engineering way; but how is a public spirit to be awakened in the community adequate to consolidate sentiment and direct effort along the proper lines?

A measure which can be made to greatly aid the solution of this problem is found in the Sanitary District law, under which the Sanitary District of Chicago has been organized.

By the requirements of this law, the Sanitary District must provide a main drainage channel from the Chicago river to the Desplaines river at Joliet, of sufficient capacity to dilute the sewage of the District with not less than 20,000 cubic feet of water per minute for each 100,000 people. This will require for a population of 3,000,000 of people, 600,000 cubic feet of water per minute. This channel will be available for an interior harbor many miles in length of unexcelled excellence, and only needs adequate connection with Lake Michigan to settle the question of marine terminals for this port. To the end of obtaining this connection the Sanitary Law also works.

To render the main drainage channel fully effective, channels for water must be made between the lake and the North and South branches, which will only require proper treatment to serve the purpose of harbor entrances.

(See Report of the "Drainage and Water Supply Commission" of Chicago, published in 1887.)

The Sanitary District has full power to make such channels in such a way as to fully subserve the needs of drainage. To meet the needs of navigation, the co-operation of the city and the United States government should be secured; and to do so should not be considered beyond the range of possibilities.

Much more complicated feats of statesmanship than is required to bring about such co-operation, have been performed: much greater expenditure of public funds has been made on works of far less importance; and far more difficult engineering works have been executed than this; though few, if any, have ever been undertaken that are more pregnant with great results to the City, the State, and the Nation.

By following out this combined work on proper lines, the Nation may aid in the development of a harbor at Chicago, which will be commensurate with the city's importance, and secure the building of a section—and the most difficult section at that—30 to 40 miles in length, of a waterway to the Gulf of Mexico; the Sanitary District of

Chicago will have finally settled the sanitary problem so far as main drainage is concerned; and the city will have solved the bridge and harbor problems at one stroke, and will be put in a position to invite the commerce of the world, and to urge the carrying out of a deep water project to the Atlantic without fear that after it is consummated, it will contribute more to the benefit of a rival port than to its own prosperity.

By solving the bridge problem, it removes the fetters which now repress a healthy internal development, and opens a field before it, adequate for the heritage of a city soon to count its inhabitants by millions.

Of all the questions which have faced the City of Chicago, none will compare with the combined problem of commerce and drainage, in importance. In the wisdom and resolution of the public officers charged with directing the course of the city, and of the Sanitary District, depends the commercial future of Chicago to an extent comprehended by none.

THE RAILWAY PROBLEM.

In Chicago, to use the words of an illustrious American Statesman, "A condition, not a theory, confronts us."

Agencies which have combined to make the unprecedented growth and prosperity of this great City possible, have become so entangled with the resulting development as to become a menace to the good of the community. The interdependence between these agencies and the City remains a fact and the questions which must be solved pertain to safety to life and limb, public convenience and economy in the methods of transporting people and merchandise.

The railroads which come within the corporate limits are all mainly operated upon the grades of the City's streets and where these tracks cross each other it is upon the same plane. The danger of which to the general public may be made apparent by stating the deaths traceable to Railroads, these the statistics for 1890 show to have been 245 persons within the City limits. It is true that by far the greater number of these deaths occurred upon the private grounds of the railroads, where the victims, unless employees, were in point of fact trespassers tempting their fate: but this fact does not mitigate the horror of the destruction of life chronicled.

It seems to your Committee, however, to be a waste of words to attempt to present a situation which is so well understood and so personally felt by every active and intelligent citizen. What all seek is a remedy for evils which all recognize. So far as the Railroads are concerned the hope of relief lies in separating their planes of travel from

those of the streets and public highways by placing the railways upon one level and the streets upon another and also putting intersecting lines of railway upon different planes, where they cross each other. This may be done in several ways.

1st. The railways may be lifted entirely above the streets and highways to such a height that, with streets remaining at their present grades, ample head room will be afforded for all kinds of vehicular passage beneath the tracks.

2nd. The streets may be carried over the railways by means of viaducts.

3rd. The streets may be carried beneath the railways by using subways.

4th. The railways may be depressed and operated in open cuttings and the streets may be carried at or near their present grades over the tracks thus depressed.

5th. There may be a compromise between the first and third methods by which the railways may be elevated partially and the streets at their crossings of such lines may be depressed to an extent limited by the practicability of draining the depression.

Your Committee does not believe it to be consonant with practicability or sound public policy to prescribe any one of the methods here outlined, for all of the Railways entering the City, or for all portions of any one line. The conditions existing along each, and varying on different portions of the same line must all be studied and that mode of construction resorted to which will afford the relief sought with the least outlay of money and the smallest damage to public and private interests. Any wholesale attempt to revolutionize immediately the existing condition of things would result in such an increase of the fixed charges of the railroads that the public would, as a consequence, suffer in its material interests.

The popular demand is for elevated railways as a solution of the whole transportation problem and there is much to be urged in justification of such a demand. As a means of transporting passengers the elevated railway will always be popular with the traveling public, as use has demonstrated the safety of such systems and they afford to the traveller better light and a more extended view than even the surface railroad. Against their construction, however, many serious objections present themselves. From the standpoint of the City they may be objected to as limiting the use of the street which they cross or occupy. They obstruct the view and are not sightly in themselves. Their very great cost for construction and consequential damages which must be paid to abutting property owners makes it difficult to secure the investment of capital adequate for the outlay which would

be involved in any comprehensive plan for elevating Chicago's railway tracks.

The second alternative presented, that of viaducts over the railways, for all street crossings is open to very grave objections. Such structures involve a very large outlay of money for original construction and their maintenance is a perpetual tax upon the City. Property fronting their approaches is seriously damaged. The City is disfigured by such structures and the cost of cartage is increased by reason of limiting the loads which may be hauled up the approaches and thus a perpetual tax is laid upon the whole community. Hence in our opinion viaducts should only be resorted to in situations where they afford the only means of relief.

The third alternative, that of passing the streets beneath the railways by subways, the tracks remaining at present grades, is open to the same objections which lie against viaducts and our conclusions regarding the use of the two methods are the same.

The fourth alternative, that of operating the railroads in open cuttings and carrying the streets across the same at or about the existing grades is a practical solution of the problem involved which, while it cannot be urged for universal adoption, is yet so meritorious as to deserve the most careful consideration. From the standpoint of the citizen who wishes to have safe and unobstructed streets and to remove from vision all that is unsightly as the concomitant of railroad occupation this solution is the ideal one. We therefore present its claims at some length.

Owing to the fact that the natural surface of a very large area of the City is but little above the level of Lake Michigan every depressed or subterranean plan for roadways must at the outset encounter the drainage problem and our conclusions as to whether that obstacle can be overcome must first be reached and stated. We are well satisfied that this difficulty can be met without incurring an outlay which would be prohibitory or indeed serious as compared with the advantages to be secured. Two tunnels under the Chicago River which have been in use for many years, demonstrate the feasibility of keeping such subways dry; and the tunnel under the St. Clair River, which is subject to conditions much more trying than either of these, is another object lesson in confirmation of our conclusions. These practical demonstrations will suffice without multiplying examples further. For open cuttings below the line of saturation the problem is no more difficult; although in rainy seasons the quantity of water to be cared for would be increased in proportion to the area of the exposed roadway. These open cuttings would, in most sections of the City, be through clay which is nearly impervious to water, and what little

seepage there might be would be excluded by the side walls if laid in cement.

At intervals along the cut sumps would have to be provided connected by a sewer which would convey all water entering the cut to a properly located and equipped pumping station. Another apparent difficulty to be encountered in these open cuts is the interception of sewers, water and gas mains. Without any question the water and gas mains can easily be carried beneath the roadway of the cut. With sewers the problem is more difficult but we are fully satisfied that it can be successfully solved by the use of properly constructed syphons.

Disposing of the material which would be removed from these cuttings would be a very important element in the problem of construction, but by a compromise between the City and the corporation performing the work this difficulty could be overcome and good results would be attained. The street grades of Chicago are in many places too low, to admit of their being underlaid with sewers having sufficient gradients to insure a proper flow and give the best sanitary results. Our suggestion, therefore, is that the material excavated from the cuts shall be used to raise the grade of adjacent streets and property. This method of providing for a large number of tracks is in our view the most economical that can be resorted to and would effect a great saving over any method of elevated construction. The heaviest cost would be for the side walls which would cost the same for any number of tracks, or any desired width of cutting. To the railroads an objection to the depressed system would arise during the winter season from snow blockades; but this objection is not so serious as it at first appears for where, as in this City, numbers of tracks parallel each other it is imposssble to use snow plows as a means of keeping them clear and therefore large numbers of men have to be employed to shovel off and remove the snow; and this work would be more difficult or costly in depressed tracks than it now is on the surface. Without going into accurate estimates of costs based upon definite plans we are warranted in asserting that the cost of maintaining the necessary pumping works fully adequate to the task of keeping these depressed roadways dry would be scarcely more than a tithe of what is now paid for the wages of watchmen and the interest on first cost of safety appliances at street crossings with cost for repairs &c., added. Work under this system once done would constitute a permanent improvement. The street and the railway would be forever divorced, railway transit could be as rapid as any demand upon it would justify; and freight trains, long or short could be handled to suit the convenience of the railroad without obstructing any City thoroughfare. Moreover it would be altogether feasible to make the entire area above these open cuttings available for building purposes should the demand

for building space justify the outlay. To provide for such a contingency the track should be so spaced as to admit of placing supporting columns between them.

Under the head of depressed roadways we must also consider tunnels.

The substratum of Chicago is very favorable to tunnel work and from all the indications no unusual obstacles would have to be overcome. In some sections of the City rock would be encountered but the underlying stratum is mostly clay. Tunnels may be used to advantage at depths which would admit of connecting objective points by direct lines thus saving distance and time. For passenger service some motive power other than steam should be used to avoid vitiating the atmosphere. The wonderful development in the art of elevator construction makes it possible to provide for moving heavy loads and great numbers of people from one plane to another of different height without delay or inconvenience and at a very reasonable expenditure for the service obtained, and it is self evident that any mechanical methods of interchanging business between elevated tracks and the surface can be made to accomplish like results in making the interchange between any depressed system and the surface. It seems to your Committee that in disentangling the railway systems of Chicago the open cut and the tunnel will each have to play an important part in separating the planes of travel of the several roads now crossing each other at grade. Moreover with the Sanitary District of Chicago, created under the laws of the State of Illinois, in motion and working toward the accomplishment of certain definite ends, it is impossible for this Committee to refuse to recognize the inevitable conditions which the accomplishment of the plans outlined by the Sanitary District law and which are dwelt upon more fully under the head of Marine Commerce would bring about. If these plans are carried to a conclusion in their entirety then Chicago will become mainly an Island City and all approach to it from the outside world must be by bridges spanning the new channels or by tunnels under them.

The fifth alternative, that of a partial elevation of tracks and a partial depression of streets now remains to be considered.

Under some conditions this method of obtaining the relief sought may be regarded as a reasonable compromise between the citizens as represented by their legislators and executives and the corporations owning the railroads. In such cases a height of not less than nine feet from the existing street level to the bases of the rails should be insisted upon; allowing eighteen inches for the depth of floor of the bridge spanning the street and depressing the street four and one-half feet, a clear head room of twelve feet would be secured which is the head room accepted in Eastern cities in similar cases. This semi-elevated

construction would be accomplished by filling between retaining walls built upon the right of way lines. The advantage of such construction would be its cheapness and permanency as compared with the elevated system, affording as it would every facility for rapid transit and unobstructed operation of trains for a comparatively moderate outlay. The objections lie in limiting the use of streets and highways and the unsightliness of the structure. These are the ways in which the problems with which we have to deal may be solved but not without much careful preliminary consideration, negotiation and compromise.

Preliminary to effective and comprehensive work must come harmonious and concerted action on the part of the railroads. whose representatives should meet the civil authorities prepared to concede all that may reasonably be asked, and to co-operate in every well directed effort to alleviate or eradicate the evils of crossings at grade. And the representatives of the marine interests should join hands with both the civil authorities and the railroads in arriving at a final settlement of the harbor question upon a basis which would insure to the city and the transportation interests the most beneficial and lasting results. But long before all of the reforms which we hope to see as the results of a rearrangement of the planes of travel can possibly be entered upon, the people and the railroads may reap the benefit of a change in methods of doing business. No freight designed for points beyond Chicago should ever be handled in the city yards. Yards should be established outside of the city limits where all the interchange switching should be done. A centralized aggregation of yards like the Chicago Union Transfer Co., outside the city would greatly facilitate the dispatch with which this interchange business could be conducted and by the convenience of arrangement and the simplicity of movement involved, the cost of doing the work would be minimized.

The Belt roads should be used in making freight transfers between the various roads; and if the facilities afforded by the existing roads are inadequate then all the roads should unite in constructing a Belt road; all sharing in the cost of construction. This road when completed should be used as a means of interchanging business upon the basis of actual cost for the services rendered.

Your Committee ventures the following suggestions which seem worthy of study and development, viz., the organization of a Chicago City Terminal Association. To this Association the holdings of all the companies now having terminal property in Chicago to be leased upon an agreed valuation and the lessor companies to have representation in the management of the new association. The corporation thus formed to control and operate the properties acquired under its lease and also a centralized group of yards at or near the city limits,

which yards should become the Chicago terimini of the several lines now existing or to be built hereafter. Each road having a sufficient yard assigned to it. There all freight for Chicago should be turned over to the Terminal Association and delivered by it to City consignees at the yard or freight house nearest the place of business of said consignee. Freight leaving the City to be delivered to the Terminal Association properly consigned including the designation of the route and the Association to receive the same as the freight house or yard most convenient to the consignor and deliver the same to the road via which it is consigned at the outside terminal yard of said road. Were such an arrangement as this perfected a great deal could be accomplished in the way of reducing the number of railroad grade crossings, all tracks being under one management changes could be made in their arrangement which would prove most advantageous. Much of the freight which now comes into the City and is stored by the wholesale houses might be stored in warehouses (bonded or otherwise) built for the purpose at the outside terminal yards, these houses could be a part of the plant of the Terminal Association and be made to yield an income from rentals which the merchants could afford to pay. Having these houses as depots of supply merchants could sell by sample and take the stock sold from these depositories and thus a vast tonnage of bulky material be kept outside the congested areas. Under proper limitations much of the freight transfer between the congested districts and the outer terminals could be made at night. With all the railroad holdings under one management it might prove practicable and advantageous to establish one grand union passenger station or at least to reduce the number of stations to four so located as to conduce to the greater convenience of the travelling public.

INTRAMURAL RAPID TRANSIT.

In populous districts rapid transit can never be attained upon the street levels. A multiplication of street railways whether the modes of propulsion used be horse power, electric motor, cable traction, or steam; or whatever other power the future may develope will not give rapid transit; although every added line of travel increases the ability to handle a large volume of busines. Rapid transit can only be attained by resorting to elevated or depressed tracks, and all that has been said in this report about the application of these methods to the uses of standard steam railways applies with almost equal force to railways for passenger travel only. The preference of the traveller will probably be always for the elevated system because it affords better light, freer

circulation of air, and a more extended view: besides its undoubted safety as demonstrated by long use: in testimony of which see statistics in appendix as given by Col. Hain, General Manager of the Manhattan Railway Company. The objection to elevated railways for whatever purpose used have been already stated in this report and your Committee believes that such structures should not be allowed to occupy public streets except at crossings. When built they should be confined to the occupancy of rights of way procured by the corporation building them or else to public alleys, where the damage to abutting property would be minimized. The City has much to gain in the way of unobstructed street travel by the adoption of depressed ways and tunnels for rapid transit routes. And only by resorting to tunnels beneath the River can uninterrupted communication between the different divisions of the City be attained, so long as the River channels are kept open to navigation as at present conducted.

APPLICATION OF POWER IN THE RAILROAD PROBLEM.*

Up to a comparatively recent period water and steam power have been almost universally used for manufacturing and mechanical purposes, but in the use of steam there is a great waste of power without much prospect of remedying it.

Within the last few years, however, electricity, which had been previously comparatively dormant, has been rapidly supplanting steam and gas and only a cheaper method of generating it (which will, no doubt, be realized) is required to enable it to substantially take the place of steam and gas in many places where the latter are now used.

The most satisfactory and perfect success in the use of electricity has lately been attained in the underground railroad in London called the London and Southwark Sub-way, extending in a southerly direction from the monument in King William street, near the north end of London bridge, under the Thames River to Southwark. It is 3½ miles long. The report states that it was opened for business in October 1890 at a cost of $3,000,000.

Ten trains run continuously on two or three minutes headway. The road lies from 40 to 60 feet below the surface of the streets. The tunnels and the trains are electrically lighted and the trains are run by electricity, the tunnel is perfectly dry and as there is no fire or gas in it, it is claimed that the air is as pure as that of the streets.

*When the work of this Committee was assigned to its members, the application of power was allotted to Col. Roswell B. Mason and this paper is presented substantially as it came from his hands before he was stricken with the fatal illness which deprived this body of his ripe experience and time-tested wisdom.

The shafts at stations are 25 feet in diameter and in them are placed two water balanced elevators to take people to and from the platform.

The trains are run as high speed as 23 miles per hour, but in general they will not maintain a higher rate than 16 miles per hour.

No other available power could be used that could give such perfect satisfaction. The use of electricity, is still in its infancy and far greater developements in the near future are confidently anticipated, and in my estimation are sure to be realized.

The lighting of tunnels, underground railroads, streets, offices, dwellings and manufacturing establishments is already done to a considerable extent, and electricity is rapidly taking the place of horse power on our street railroads. It is entirely among the possibilities that it may take the place of steam for locomotives on our railroads, especially on short lines for suburban travel. Indeed its use may be said to be almost unlimited and it has the decided advantage of cleanliness over steam power, which is of immense importance, and it may have the further advantage of economy. In running trains, electricity is a growing power and it is difficult to realize what may be accomplished by it in the near future.

CONCLUSION.

Your Committee is met by conditions which are beyond the scope or influence of Engineering skill; passing into the domain of broad statesmanship, profound jurisprudence and able financiering. These conditions arise in the shape of corporate, civic and individual rights and economic expediency. There are in this City no less than fifteen (15) distinct rights of way owned by surface railways, and your Committee knows of but one law which can group these several lines in the occupancy of any reduced number of railway thoroughfares and terminals: that one law is the decree of self interest. These organizations can only be brought to abandon present methods and present holdings by a strong conviction that such a procedure would mean increased revenue by reducing expenses and increasing conveniencies and facilities for transacting business. It is within the power of the law in the enforcement of the great principle which demands that you should so use your own as not to injure another or infringe upon anothers right, to compel these several lines to so conduct their operations as not to endanger the lives or limbs of the people, who everywhere in this broad land enjoy the right to life, liberty and the pursuit of happiness. But it does not seem to be within the province of the law to prescribe specifications covering the details involved in the attainment of this great end. The law may order improvements of such obvious merit that as an abstract conception all must approve:

but if the execution of these improvements involves an outlay beyond the financial ability of the parties in interest then the majesty of the law is mocked by the poverty of the subject of legislation. In conclusion we urge that it be demanded of the proper authorities that a commission of Engineers be created to work up this whole subject. And that their work may be more intelligent and practical, that they be given able counsel in all questions involving legal rights and legal methods of procedure: to the end that the conclusions reached may be authoritative for their broad and comprehensive wisdom. And further that prompt measures be taken to secure such legislation as will make the plans and conclusions of the Commission operative and binding so that the improvements recommended may be entered upon at once and pushed to completion as fast as is consistent with the welfare and the rights of all of the parties in interest.

We the undersigned concur in the foregoing report with such exceptions as are noted opposite our names:

(Signed) E. L. Corthell, - - Except as to the Railroad Problem.

" Isham Randolph, - - Except as to River and Harbor.

" Benezette Williams,

" Hiero B. Herr.

" Wm. Sooy Smith, - - Except that I do not think Engineers should do so much professional work without pay and unasked by the public, or by those directly and especially interested in the problems discussed.

" Oliver B. Green

APPENDIX.

MARINE COMMERCE.

TABLE I.

The freight tonnage passing through the Sault St. Marie Falls canal during the year ending June 30th, 1890, was 8,288,580, and that for the Detroit river for the season of 1889 was 19,717,860 tons classified as follows:

From U. S. Census Bulletin.

	Sault St. Marie.	Detroit River.
Building stone	40,829	
Coal	1,894,483	5,313,419
Copper	36,086	
Iron Ore	4,404,835	6,610,293
Pig and manufactured iron	72,163	94,337
Salt	31,164	47,737
Silver ore	5,905	
Lumber	541,591	2,545,792
Laths		23,699
Shingles		27,668
Barley		38,294
Corn		1,777,750
Flour	254,088	655,395
Oats		262,896
Wheat	583,794	824,451
Grain other than wheat	76,065	
Grain other than wheat, barley, corn and oats		105,412
Hides	455	
Wool	2,597	
Miscellaneous and unclassified	344,425	1,390,717

TABLE II.

By the official report of Gen. O. M. Poe, the freight traffic through the Sault St. Marie Falls canal during the past four years has been as follows:

YEAR.	Freight tonnage net.	Valuation of freight tonnage.	Average distance carried.	Total cost of transportation.	Cost per ton mile.
					Mills.
1877	5,494,649	$79,031,758	811.4	$10,075,153	2.3
1888	6,411,423	82,156,020	806.9	7,883,077	1.5
1889	7,516,022	83,732,527	790.4	8,634,246	1.5
1890	9,041,213	102,214,949	707.2	9,472,214	1.3

Total tonnage for 1891, 8,888,795.

The total iron ore shipments by lake from Lake Superior mines for 1890 amounted to 8,357,781 gross tons and by all rail, 681,158 gross tons. Total, 9,038,939 gross tons. (Marine Review.)

TABLE III.

The net tons of freight passing through the Suez Canal for the years 1886, 1887, 1888, 1889 and 1890, with the number of vessels, was as follows:

1866	3,100 vessels.	5,767,655 tons.
1887	3,137 "	5,903,024 "
1888	3,440 "	6,640,834 "
1889	3,425 "	6,783,187 "
1890	3,389 "	6,890,014 "

TABLE IV.

The classification according to size of the vessels composing the steam and sailing tonnage on the lakes, June 30th, 1890. From the report of the Commissioner of Navigation for 1890.

Class.	SAILING.		STEAM.	
	Number.	Tonnage.	Number.	Tonnage.
5 to 100 tons	452	17,831.49	808	29,589.27
100 to 500 "	633	168,530.15	320	75,655.82
500 to 1000 "	164	113,551.39	112	87.009.05
1000 to 2500 "	23	28,852.92	272	439,786.85
2500 and over			8	20,881.96
Total	1,272	328,655.96	1,527	652,992.95

TABLE V.

Compiled from Census Bulletin No. 29. Summary of the changes in the floating equipment on the great Lakes since 1886, as relates to number and tonnage.

Classification of Vessels.	Number of Vessels.			Net Tonnage of Vessels.		
	1886.	1890.	Increase or decrease per cent.	1886.	1890.	Increase or decrease per cent.
STRUCTURE.						
Side Wheel Steamers	43	42	—2.3	14,150	16,949	19.3
Propellers under 1,000 tons	335	431	28.6	177,402	154,292	—13.00
Propellers between 1,000 and 1,500 tons	72	122	69.4	86,728	151,611	74.8
Propellers over 1,500 tons	21	110	423.8	34,868	188,390	440.3
Tugs	466	448	—3.9	11,737	12,520	6.7
Schooners	730	577	—21.0	183,792	152,620	—13.7
Barges	330	325	—1.5	125,975	144,038	14.3
MATERIAL.						
Steel	6	68	1033.0	6,459	99,457	1439.8
Iron	35	39	11.4	22,714	23,673	8.6
Composite	2	13	550.0	63	13,554	21414.0
Wood	1954	1935	1.0	605,416	688,676	13.7
SAIL OR STEAM.						
Steam vessels	937	1153	23.0	324,885	523,702	61.2
Salinig vessels	1060	902	—15.0	309,767	302,658	—2.3
	1997	2055	2.9	634,652	826,360	30.2

TABLE VI.

Giving a record of boats built at Lake Ship Yards since 1886, including those under contract for 1889-91.

(*See Report of Commissioner of Navigation for 1890, page 366.*)

YEAR.	Number of boats.	Capacity gross tons.	Average capacity gross tons.	Valuation.	Average valuation.
1886-87	31	65,750	2,121	$4,074,000	$131,417
1887-88	60	108,525	1,809	8,325,000	138,750
1888-89	59	100,950	1,711	7,124,000	120,695
1889-90	56	124,750	2,228	7,866,000	140,464
Under contract 1890-91	38	77,950	2,051	5,337,000	140,447
Totals and Averages	244	477,925	1,950	32,726,000	134,123

TABLE VII.

Tonnage of vessels built on the Great Lakes for each of the several years.

(*See Report of the Commissioner of Navigation for 1890, page 351.*)

	Tonnage.
Year ending June 30th, 1857	51,498
" " " " 1858	31,642
" " " " 1859	6,180
" " " " 1860	11,992
" " " " 1861	23,467
" " " " 1862	53,804
" " " " 1863	67,972
" " " " 1864	49,151
" " " " 1865	36,641
" " " " 1866	38,204
" " " " 1867	39,679
" " " " 1868	56,798
" " " " 1869	49,460
" " " " 1870	37,258
" " " " 1871	43,897
" " " " 1872	44,611
" " " " 1873	92,448
" " " " 1874	91,986
" " " " 1875	29,871
" " " " 1876	16,124
" " " " 1877	8,903
" " " " 1878	11,438
" " " " 1879	15,133
" " " " 1880	22,899
" " " " 1881	73,504
" " " " 1882	58,369
" " " " 1883	28,638
" " " " 1884	30,431
" " " " 1885	26,826
" " " " 1886	20,400
" " " " 1887	56,888
" " " " 1888	101,103
" " " " 1889	107,080
" " " " 1890	108,526
Total	1,537,623

TABLE VIII.

Total documented shipping of the U. S. and of the United Kingdom to June 30th, 1890, taken from Report of the Commissioner of Navigation.

Ships in Foreign Trade	1,527 of	946,695.44 tons
" " Coastwise Trade	15,748 "	2,051,925.00 "
" " Western Rivers	1,223 "	294,446.59 "
" " Fisheries on Seacoast	1,459 "	68,366.41 "
" on Northern Lakes	3,510 "	1,063,064.00 "
Totals	23,467	4,424,497.44
Total Pacific Coast Shipping Including Fisheries Included in Above	1,402 "	428,391.55 "

The total documented tonnage on the Lakes, June 30th, 1891, 1,154,870.

Total shipping, United Kingdom, steamers 100 tons gross and sailing vessels of 100 tons net, in 1889.

Steam	5,574 of	7,774,644 gross tonnage.
Sail	3,593 "	2,467,212 net "
Colonies, Steam	829 "	461,210 gross "
" Sail	2,075 "	894,040 net "
Total British Empire	12,071	11,597,106

Or 52.34 per centage of the world.

TABLE IX.

Showing the average rate of freight per 100 pounds and per ton mile on wheat from Chicago to Buffalo by Lake and from Chicago to New York by Lake and Erie Canal, and by all rail—1858 to 1890 inclusive—compiled from Transportation Routes to the Seaboard, from the Report of the Senate Select Committee on Interstate Commerce, and from Chicago Board of Trade Reports. Rates by Water, Chicago to New York, includes Transfer Charges at Buffalo.

Year.	Lakes, Chicago to Buffalo, Distance, 889 Miles.		Lakes & Canal, Chicago to New York, Distance, 1,384 Miles.		Rail, Chicago to New York, 979 Miles, viz.: L. S. & N. Y. Central.	
	Cents per 100 lbs.	Mills per ton Mile.	Cents per 100 lbs.	Mills per ton Mile.	Cents per 100 lbs.	Mills per ton Mile.
1858			26		64	
1859			28		58	
1860	16	3.6	43	4.7	58	12.2
1861	20		43		69	
1862	18		45		30	
1863	12		39		82	
1864	16		47		100	
1865	15	3.7	44	6.4	78	16.7
1866	23		50		77	
1867	13		37		74	
1868	13		42		63	
1869	11		40		59	
1870	11	3.1	30	5.7	50	13.2
1871	11		36		53	
1872	18		44		58	
1873	15		32		52	
1874	6.7		24		44	
1875	6.3	2.5	19	4.5	40	10.1
1876	5.4		16		28	
1877	6.3		18		34	
1878	5.5		17		30	
1879	7.9		20		30	
1880	9.1	1.6	22	2.7	33	6.3
1881	5.7		14		24	
1882	5.8		12		24	
1883	5.8		15		27	
1884	4.0		12		22	
1885	4.4	1.1	11	1.9	22	4.8
1886	6.3		15		25	
1887	7.0		16		26	
1888	4 6		12		24	
1889	4.4		11		25	
1890	3.4	1.1	11	1.9	24	5.1

TABLE X.

Average Freight Rates on Articles of Commerce Passing Through the Sault St. Marie Canal for the Years Given, Taken from the Official Report of Gen. O. M. Poe, Dated, May 14th, 1891.

Commodity.	1887.	1888	1889	1890
Coal per net ton	.90	.70	.47	
Flour per barrel	.29	.17½	.18	.45
Wheat per bushel		.03½	.04	.13
Grain including wheat, corn and oats for 1887 and corn and oats for 1889, per bushel	.07		.03¾	.03
Corn per bushel		.04⅓		.03
Oats per bushel		.05		.02
Manufactured iron, including Pig for 1887 per net ton	2.35	1.80	2.10	1.34
Pig iron per net ton		1.30	1.45	1.35
Salt per barrel	.18	.16	.18	.15
Copper per net ton	2.60	2.35	2.25	2.38
Iron ore per net ton	1.75	1.28	1.14	1.10
Lumber per M. feet, B. M	4.00	2.30	2.70	2.38
Bullion per net ton	3.00	1.90	1.90	2.25
Building stone per net ton	1.15	2.05	2.07	2.00
General merchandise per net ton	4.00	3.00	3.00	2.75
Average distance freight was carried miles	811.4	806.9	790.4	797.2
Average rate of freight per ton mile, terminal charges included	.0023	.0015	.0015	.0013

TABLE XI.

Showing the Commerce of the Port of Chicago, Including South Chicago, for the Year 1889. *Compiled from the U. S. Census Returns.*

Kind of Commodity.	Receipts.		Shipments.	
	Tons.	Per Cent.	Tons.	Per Cent.
Wheat			312,203	32.21
Corn			1,769,621	91.71
Other grains			457,095	90.85
Mill Products	1,860	0.19	228,138	25.52
All other farm products	8,994	16.00	51,984	46.39
Coal	1,529,364	25.75		
Iron ore	731,188	9.59		
Stones, all kinds	18,176	5.85		
Salt	128,948	43.49	8	
Other products of mines and quarries	1,600	2.75		
Animal products	146	0.22	55,985	92.00
Lumber	2,588,004	37.74	2,106	0.04
Manufactures, miscellaneous merchandise and other commodities	261,693	17.24	36,925	3.24

TABLE XII.

Rated Tonnage of the Port of Chicago, Compiled from the Reports of the Department of Public Works.

Years.	Total Number of Arrivals and Clearances.	Tonnage.	Average tonnage of Vessels.
1858	13,650	3,284,703	240
1862	14,687	3,847,246	262
1863	17,136	4,333,832	253
1864	17,762	4,339,770	244
1865	20,179	4,199,133	208
1866	22,199	4,620,092	208
1867	24,370	5,101,032	209
1868	26,399	6,005,403	227
1869	27,602	6,273,346	227
1870	25,172	6,033,207	239
1871	24,632	6,178,336	250
1872	25,355	8,077,542	240
1873	22,734	6,564,714	290
1874	21,547	6,329,711	294
1875	21,095	6,279,055	298
1876	19,249	6,167,336	320
1877	20,517	6,585,415	321
1878	20,989	7,239,673	345
1879	23,873	7,757,394	325
1880	26,520	9,154,351	345
1881	26,005	8,762,247	336
1882	26,977	9,854,949	362
1883	23,982	7,793,337	325
1884	22,823	7,508,696	334
1885	20,542	7,306,222	355
1886	22,372	7,877,080	307
1887	23,973	8,749,852	365
1888	22,095	8,890,658	402
1889	21,788	10,267,831	471
1890	20,133	10,116,051	502

TABLE XIII

Giving Frontage and Areas of Property along Chicago river and branches, between Fullerton Avenue and Thirty-ninth Street, and east of Western Avenue. Omitting Street Ends; Compiled by the aid of Raschers Insurance Map of Chicago. Taken from "The Lakes and Gulf Waterways" by L. E. Cooley.

Class.	No. of Each.	Frontage Miles.	Area Acres.	Remarks.
R. R. Property	23	2.5	146.1	
Lum. Yds. & Bl'g. M'ls	147	13.8	454.4	
Warehouses	28	1.0	21.2	
Elevators	27	2.7	48.6	Cap'y in bu. 29,175,-000.
Coal Yards	41	2.1	51.1	
Stone Yards	22	1.0	23.5	
Tanneries	13	0.7	20.7	
Manufactures	41	4.0	191.2	
Miscellaneous	27	2.0	35.2	
Vacant	27	2.3	30.7	
Landing Docks	5	0.4	4.7	
Totals	401	32.5	1076.7	
Unclassified		5.1	168.8	S. of 39th & S. side of West Fork.
Grand Total	401	37.6	1245.5	

APPENDIX B.

Mr. F. K. Hain, General Manager of the Manhattan Railway Company, gives the following valuable statistics:

"Since the opening of these lines up to January 31, 1891, we have carried one billion, one hundred and thirty-four million, one hundred and three thousand four hundred and seventy-three passengers (1,134,-103,473) and but one passenger lost his life after boarding our trains, and that one through his own carelessness in sitting on the safety chains between the cars and falling under the train."

STATISTICS COLLECTED BY THIS COMMITTEE:

Number of persons killed in Chicago and Cook Co., during the year 1890 by steam and street-car railroads. List taken from coroner's records:

	CITY.	COUNTY.		CITY.	COUNTY.
C. & N. W.	45	64	Chi. & G. Trunk	8	8
C. M. & St. P.	20	23	N. Y. C. & St. L.	6	7
Wis. Central	0	8	Belt Line	4	5
P. C. & St. L.	8	8	U. S. Yds. & T. C.	9	9
Ill. Central	28	33	Chi. & Atlantic	1	1
L. S. & M. S.	20	21	L. N. A. & Chicago	1	1
Mich. Central	12	12	Chi. & G. Western	1	1
B. & O.	4	5	C. & Calumet	0	3
P. Ft. W. & Chi.	9	10	Wabash	0	1
C. & E. I.	3	4	Pullman	2	2
Chi. & Alton	4	9	C. St. P. & K. C.	1	2
C. B. & Q.	30	36	Ill. Steel Wks. R.R.	8	8
Santa Fe	3	4	Elgin J. & East	0	1
C. R. I. & P.	9	12	C. & N. P.	2	2
C. & W. Ind.	5	5			
	200	248		43	51
				200	248
Totals				243	299

Killed by street-car lines:

South Side cars	17
West Side cars	6
North Side cars	12
Total	35

Killed in Chicago steam cars	243	
Killed in Chicago street cars	35	
Total number	278	
Total number killed in Cook county		299

Classified as follows:

Passengers	40
Employes	53
Others	206
	299

200,000,000 passengers in 1890 all lines.

MINORITY REPORTS.

THE RAILWAY PROBLEM.

The undersigned agrees with the views of the majority of the Committee, except in respect to two features of the report:

1st.—He cannot agree in respect to the radical enlargment of the Erie Canal for deep draft vessels, believing this project to be entirely impracticable both as to construction and operation, as well as in respect to its immense cost.

2nd.—He must decidedly dissent from the views of the Committee in respect to the solution of the railway problem, and therefore submits the following as his views on this subject:

The writer has not only given careful attention and study to the terminal conditions now existing in Chicago and in other cities of the United States, but he has also studied the question of terminals and complicated railway stations in Europe. The methods adopted in Europe and used for many years there to facilitate both the railroad and the marine commerce, and to make safe the street traffic, present many features applicable to a city like Chicago.

In England the law prohibits grade crossings of any kind. The railroads are carried over or under each other. The streets, roads, and even the farm roads, are placed over or under the railroads. It would burden this report to give details and extended illustrations of the methods employed, but a few prominent examples may be given. Near Liverpool, on the London and North-Western Railway, at Edge Hill, where there is a very extensive yard for making up freight trains, an ingenious plan has been recently carried out which avoids railroad grade crossings by carrying the tracks over or under each other in making connections, so that this extensive yard can be operated without interfering with the business on any of the main lines of the railroad. Another prominent and well known example is Clapham Junction, near London. At Manchester, at the London Road station, the freight trains come in on a high level. The cars are lowered to the low

level of the streets, where they can be reached by drays. At the great Central Station of the Caledonian Railroad at Glasgow there is an elevated entrance. At Queen Street Station of the same city, the entrance is made by an elevated structure, and underneath, crossing at right angles, is a belt railroad largely underground; and in order to make a still better entrance into the city, one railroad is building a tunnel under Argyle Street, one of the main streets of the city. At Birmingham a union station is provided in the center of the city and the entrance is by subways from either direction. In London every railroad is brought into the city in such a way as to entirely avoid grade crossings and the entrance is always by overhead structures, or by tunnels or subways, several of the lines cross each other and many of them connect with the Metropolitan District Railway, which is largely an underground road. At the White Cross Station, St. Pancras, Broad Street, White chapel, Bishopsgate, and several other stations, there are special hydraulic appliances for handling cars from a high level to a low level or the reverse. With these hydraulic lifts are capstans, traversers, turntables and other appliances for moving the freight cars across or along several tracks to the desired position for loading or unloading. The universal opinion of Railroad men in England is in favor of the use of hydraulic plant for handling freight cars. Hydraulic lifts are also used in passenger stations not only in England but on the Continent, in handling baggage and express, and postal matter from one level to another, and also for transfer by means of subways in the stations from one track to another without crossing the tracks at grade. To still further prevent the crossing of tracks by the public, the stations, in England at least, and generally in large stations on the Continent, are so arranged that it is unnecessary for any purpose for passengers to cross the tracks at grade; overhead bridges and subways, well lighted and convenient, being provided for passengers in taking or leaving trains. All the arrangements for operating the road with safety to human life, including complete interlocking signal systems, are so perfect in England that the fast express trains often run with a speed of 60 miles an hour through large cities, past great stations, where there are crowds of passengers and trains on other tracks, without accidents. It is the general opinion of railroad men there that all the precautions taken by them are absolutely required for the safe and prompt movement of trains and the proper transaction of their business.

It is now necessary to examine briefly into the conditions existing in Chicago in order to show the great contrast there is with the conditions above described in European cities. The rapid growth of this city in the last 50 years, raising it from a village to a great metropolitan center, has brought about most unusual commercial conditions.

It is still growing with greater rapidity than, probably, that of any other large city in the world except possibly Berlin. Compared with other great cities of this country, the ratio of increase in population in the last decade has been nearly three times that of New York, nearly four times that of Philadelphia, of Boston, and of St. Louis. Nor has the time come, as it does eventually to all great cities, when it has ceased to grow by increasing increments. The great advance in population is still too great to be arrested for the next two decades. At least, it may be safely estimated that the growth of this city, for each decade in the future, will not be less than one million. Still further bearing on the railway problem of this city is the fact that it is the largest city of the northern division of the United States, the population of which is, by the census of 1890, over twenty-two millions of people, and that the increase in this grand division of the United States is greater than in that of any other.

On its streets are more miles of double track horse and cable railroads than on the streets of any other city. The magnitude of its marine commerce is given elsewhere in this report.

It is the greatest railroad center in the United States, probably in the world, as far as mileage is concerned. The length of main lines of railroads that terminate at this city is over 54,000. The magnitude of its freight business is also very great. In 1889 there were received and forwarded four and one-quarter millions of freight cars, making the daily handling nearly twelve thousand cars. There were moved over forty-three million tons of freight. There were over eighteen million passengers moved over its main lines, and on its suburban lines nearly eleven millions. A glance at the map of Chicago shows that the lines of tracks are interwoven most intricately, and in several localities, monopolize extensive areas. In Chicago 95 per cent. of the street crossings are at grade and the grade crossings of the roads with each other add immensely to the danger to life and limb and make the burden of delay to traffic a costly item in the operating expenditures of the roads. An attempt, unsystematic and desultory, has been made to raise the streets at points of great danger above the railroads by means of viaducts, of which there are 29. The following facts are very suggestive of delay and danger, especially when compared with their entire avoidance by the English railroads as above described. The main lines of the Chicago railroads cross each other at grade at over 100 points. These main lines cross sidings or yard tracks at over 30 points. The lead tracks running into yards cross main tracks or sidings at more than 120 points. There are, as a partial protection to the public, 487 gates at crossings. It is difficult to ascertain how many travelled streets are crossed by railroads, but there are probably one thousand or more. According to statistics stated elsewhere in this report, there were

last year on these grade crossings over 200 people killed. The growth of the railroad traffic keeping pace, as it must necessarily do, with the growth of the population, has brought about the greatest difficulties in handling this business. The areas of the city freight yards have become altogether too restricted for their purposes. The building of belt railroads has alleviated the pressure to a certain extent. One of these belt railroads, the St. Charles Air Line, is in the heart of the city and crosses its main avenues and streets at grade. The railroads make transfers with each other through the Union Stock Yard tracks. The Western Indiana Belt, in the outskirts of the city, is situated so as to relieve to some extent the city terminals, and this is shown by the fact that, since 1884, its business has increased from 223,757 cars per annum to 557,752 in 1890. There has recently been put into operation several miles of another belt railroad, called the Calumet Terminal, which also now is doing a considerable transfer business. There is still another, the Elgin, Joliet & Eastern, about 30 miles from the city, which runs from the lake on the north to the lake on the south-east and has connection with all of the railroads entering the city. Although this road has been opened but a short time, the necessities for transfers between the various railroads is bringing to it a large business. It is, however, to be regretted that the railroads entering the city persist in bringing much of their through business into the city for transfer, blocking their own and others' business and the street traffic as well. Useful as these belt railroads are in diverting from the busy parts of the city the freight which is not destined for consumption here, they are not a large factor in relieving the congested condition of the city terminals, for the reason that the products required for the city itself, for its own comsumption and business are so rapidly increasing that the present restricted and inconvenient terminals, cannot handle the business promptly or economically; and it is discouraging to note that, except at extraordinary expense, the areas occupied by the railroads for freight purposes cannot be very greatly extended on account of their proximity to very valuable property.

From the information given above, it will be apparent that the greatest evil, (which, in some way, must be cured or else abated), is the danger to the street traffic and the inconvenience as well, both to the public and the railroads, of the grade crossings. Every new street that is opened, the annual increase of travel on all the streets crossing the railroads, the increase of trains and the length of trains, and the increase in the switching and otherwise handling of cars, constantly increase the delays and dangers. When the whole situation is known, and the one fact is stated that this city is growing in population at the rate of *one million per decade*, the extraordinary obstacles in the way of both railroad and street traffic will be appreciated.

The question now arises, what shall be done to solve this difficult problem. The writer has carefully studied the entire situation and can see but one practicable plan and that is, to adopt at once the principle and rule of raising the railroad tracks to a suitable height above the streets, and to cease the unsystematic and ill-advised method of raising the streets here and there, by means of viaducts of great cost, occasioning great damage to property and converting an otherwise level city into one of abrupt undulations. The writer would suggest that, in order to avoid the construction of an elevated railway for *each* of the railroads, they should be combined into three groups of elevated railroads, one entering the city from the south and south-west, one from the west and one from the north.

It is evident, from the fact that the largest number of railroads enter the city from the east, south and south-west, that the elevated entrance from these directions should be of large dimensions. An elevated road with six to ten tracks on its main stem entering the city as far as advisable, would be required for the immense business that enters from these directions over the present surface tracks of the Lake Shore and Michigan Southern, the Rock Island & Pacific, the Western Indiana and its tenant roads, the Ft. Wayne, and the Chicago & Alton, the Chicago, Madison & Northern and the Atchison, Topeka & Santa Fe. This would embrace nearly all the roads coming from the east, from the south and from the south-west, except the Illinois Central and its tenants, which enter the city along the lake front. In order to adapt to this elevated entrance those methods which have been found practicable and economical in Europe, the clear height of this elevated entrance above the streets should be sufficiently great to give a free and unrestricted movement of street traffic under it. It should be floored over, beneath the tracks, by a solid steel and concrete construction so that the extensive area beneath could be used for yards for the various railroads or for warehouse and other similar purposes. Connected with this, at points where the present surface areas covered with tracks would not in any way interfere with the street traffic, could be arranged extensive freight yards. The cars entering the city on this elevated structure, whose destination is for city delivery, (and no others should enter), could be lowered to the tracks beneath the structure by means of hydraulic or compressed air lifts. To avoid the use of locomotives on the low level tracks at the surface of the ground, hydraulic turntables, capstans, and traversers, could be used just as they are in Europe. One immense installation, with its pipes in suitable conduits of good size, running the entire length of this elevated structure, six or eight miles, with auxilary accumulators at suitable points, would economically and promptly handle the entire business of the railroads, and would also furnish power for handling

goods in warehouses, manufactories and various industries that might be established along the line of this elevated entrance. The freight stations for all goods except the most bulky, like coal, lumber, stone, structural iron work, etc., should be built several stories in height and in the most substantial manner, so that by car elevators, the goods could be placed quickly and economically on any desired floor. This could be done by the method in use in Europe, as at the Broad Street station of the London & North-Western Railway in London, which is five stories high, the goods being raised and lowered on platforms operated by hydraulic power. Or, to still further avoid handling as much as possible, the carts and drays, with the draught animals could be raised bodily to the required floor for loading or unloading, and there moved where desired. Or, where there were only partial dray-loads, the freight could be loaded from the drays on to small platform cars which could then be lifted to their proper floor and there moved to the point of loading or storing by capstans and traversers as above, the goods being unloaded and loaded by power cranes. The most bulky goods could best be handled on team tracks on the surface of the ground, the cars being lowered by lifts. By means of hydraulic apparatus, the cars could be quickly and economically moved over extensive yards underneath and near the elevated tracks. Freight like long piles or bridge girders, loaded on two or three cars, could be promptly and economically handled by hydraulic travellers. In Europe, men who have been engaged many years handling freight by similar methods, agree in the opinion that at least fifty per cent. is saved by the use of hydraulic plants and that in many cases the work could not be done at all by the methods usually employed in this country. In many localities in Chicago the methods above stated would handle freight from 70 to 80 per cent. cheaper than by the present methods.

It is suggested that the present crude and expensive methods of handling marine commerce along the docks might be discontinued and the business much more conveniently and economically handled by hydraulic plants like those employed at Hamburg, Antwerp, Marseilles, Liverpool, and many other European cities.

In grouping and rearranging the railroad tracks and adapting them to new conditions and requirements, it will no doubt be found advisable to reconnect the railroad tracks and the marine facilities in such a manner as to greatly improve on the present methods. Even grain elevators, coal and ore docks, and lumber yards, could, no doubt, be rearranged so as to greatly increase the present facilities and reduce the expenses. Possibly in some instances, like the present extensive lumber yards on the West Fork, the hydraulic apparatus might be arranged so as to maintain the tracks on their present grade

and in their present location. No doubt at points where peculiar conditions require it, inclines of easy grade could be built leading down from the elevated structures to the present surface of the ground, so as better to subserve the interests of certain industries, especially along the river, where there would be no interference with the street traffic.

As to the two smaller groups of elevated roads from the west and north, combining all of the roads coming from these directions, the method should be adhered to of an elevated entrance wherever the present conditions of tracks, streets, viaducts and the river will permit. This would give three great elevated passenger terminals which should be so located that they might be conveniently united by a connecting elevated railway, so that passengers coming into the city from one direction and desiring to pass through to railroads leaving on opposite sides of the city, could make the transfer without the inconvenience of omnibuses, street cars, street vehicles, or on foot, as now.

If, in connection with the important work now contemplated and under charge of the Board of Trustees of the Sanitary District, there should result the replacing of a large number of swing bridges by fixed bridges, as the Committee has recommended, the connection between the elevated railroad entrance, above suggested, could be much more conveniently arranged. There should, in any event, in the future, in no instance be permitted inside the city limits, any more grade crossings. All these changes in the traffic conditions could not, of course, be made in one year, or two years, but they should be made as the railroads and the city could jointly furnish the means for the work, and the expensive and unwise plan of building viaducts over the railroads should be at once abandoned.

There is no doubt in the mind of the writer, that an intelligent study of the subject, adapting the proposed methods to special cases, and a cordial co-operation between the railroads, and between the railroads and the city, would lead to a satisfactory introduction of the elevated plan, and that such a plan would be mutually convenient to the railroads that handle the goods and the people that use them, and the same would apply to an elevated passenger terminal.

Two questions, however, arise: first, who are to meet the extra expenses involved by a general rearrangement of these traffic conditions? It would seem to be equitable that those reaping the benefits should share in the expense, and that consequently they should in some just way be divided between the railroads and the people. And second, what will be the damages enforced by private citizens in the courts? It goes without saying that while we are all patriotic in the abstract, we are likely in each case to insist upon all the damages that litigation

can give us. This selfishness and want of forbearance on the part of property holders may lead to such an enormous amount of damages as to make prohibitory the adoption of any wise plan for ameliorating the present most unbearable conditions. Let the betterments resulting from the new and better methods be assessed equitably upon those benefitted.

In the opinion of the writer the plan suggested will effectually and permanently solve the Railway Problem of Chicago. After much discussion and close study of the subject, he strongly recommends its adoption and application as rapidly as circumstances will permit.

Signed. E. L. CORTHELL.

RIVER AND HARBOR.

Should the plans of the Sanitary Commission for a North channel connecting the North Branch of the Chicago River and a South channel connecting the South Branch of said River with Lake Michigan ever reach fulfillment, then and not until then, or at least not until that consummation becomes inevitable, can we accept the solution of the harbor problem wrought out on the lines laid down in the majority report. Until that solution is assured we consider the Lake Front as affording the proper and the eventual site of Chicago's harbor. We use the same Lake Front in no contracted sense but make it so comprehensive as to include the whole range of water front from Indiana street to the mouth of the Calumet River.

Chicago to hold her supremacy in Lake commerce must have a harbor of depth sufficient to accommodate the increased and still increasing draft of vessels plying between the ports of our fresh water seas and likely before the next generation passes away to pass back and forth between these inland ports and the harbors of the World's five oceans. This need can be met fully upon the Lake Front. The cost of there creating such a harbor as this City needs is calculable, its execution is practicable and the resulting good to the city and state will be measured in millions of increased wealth.

The statistics given us show a dockage along the river front of $37^{6}/_{10}$ miles and an area used in connection therewith of $1245\frac{1}{2}$ acres. Should commerce ever demand such a length of dockage and such an area for business uses as these figures show, the demand can be met upon the Lake Front. Four miles of that frontage filled out to a width of three-quarters of a mile and docked upon a systematic plan, far excelling in convenience any harbor on the whole range of the Lakes could be made to yield a frontage of 36 miles and still provide an area of 1456 acres for lumber yards, elevators, factories, etc.

Such a harbor would have to be protected by an outside breakwater which should be carried through from the mouth of the Chicago River to the mouth of the Calumet River; thus securing a protected waterway between the two harbors and making them practically one. To accomplish this about eleven miles of breakwater would have to be built.

This done Chicago would indeed have a harbor which would be wealth producing and a source of pride to every patriotic citizen.

Having provided such a harbor the fate of the River should be settled for all time by the abandonment of swing bridges and the substitution therefor of fixed bridges, at such a height above the water level as to admit of the free passage of tugs with their tows of lighters, scows or barges. The channel so treated would remain to serve a most useful purpose.

The communication of this harbor with the interior must be considered. No railway should be allowed to enter this new domain at grade, but an adequate system of tracks should be provided under restrictions which would forever prevent their becoming a monopoly controlled by any connecting line. Every Railroad entering Chicago should have the right to use these tracks upon terms of equality with all competitors. These entering tracks may be elevated or depressed as will best meet the conditions which will develope. When we have such a harbor as this and the River spanned by fixed bridges as we have suggested, interchange of business between different portions of the City having water facilities can be made by the use of barges; and cars even can be moved from one point to another in the same way, in accordance with common practice in Eastern ports.

It is true that "One ship load of 2000 tons represents 100 car loads and 500 truck loads" and that were this tonnage hauled through the streets it would cause vastly more obstruction to street travel than "one vessel passing through the bridges." But if the tracks, over which communication is had between the harbor and the rest of the World, are elevated above or depressed below the street levels, it will not matter to the users of the streets whether one hundred cars or many times that number are moved over them. So far as trucking is concerned, it is the most expensive method of transportation and hence would not be resorted to for long hauls. Distribution in bulk would therefore be made throughout the City, as it is today by rail or water; and the trucks would bring into the congested districts only the materials and merchandise which the locality would consume in the ordinary course of trade.

When the æsthetic side of this question is presented, it is elbowed by the very prosaic fact that no city can thrive upon the beautiful alone, and the prosperity of Chicago can never be sacrificed to gratify

the tastes of the few who have wealth and leisure to bestow upon such enjoyments as lovely drives and pleasing landscapes with wide expanse of waters for a background. Certainly with Parks and drives stretching for miles along our Northern water front, and with the grand domain of Jackson Park forever set apart and defended from the defilements of commerce, Chicago should rest content in the proud assurance that no other City in the World can show such a wealth of Park and Boulevard; and while cherishing this just pride she should remember that these things will not save the scepter which she holds today as Queen of the Lakes, unless she shows her worthiness to wield it by providing a harbor to receive the leviathans of commerce which could find no place to anchor if they sought her port today.

Signed. ISHAM RANDOLPH.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

BOSTON SOCIETY OF CIVIL ENGINEERS.

Annual Dinner.

March 9, 1892:—The tenth annual dinner of the Boston Society of Civil Engineers was served at the American House, Boston.

An informal reception was held at 5 o'clock and at 6 o'clock 100 members and guests sat down to dinner.

President Frederic P. Stearns sat at the head of the table having on his right and left, as the principal guests of the evening:—Prof. Elihu Thomson, President of the Thomson-Houston Electric Co.: President E. H. Capen of Tufts College; Col. H. G. Prout, Editor of the Railroad Gazette: Dr. S. C. Chandler, representing the Boston Scientific Society; Maj. W. R. Livermore, Engineer Corps, U. S. Army: Mr. H. G. Holden, President New England Water Works Association: Mr. E. C. Cabot, President, Boston Society of Architects; Dr. H. P. Walcott, Chairman, State Board of Health and Mr. Allen Hazen, Chemist, State Board of Health.

President Stearns made a short opening address in which he congratulated the members on the steady growth of the Society and the healthful condition of its treasury. In closing he presented Prof. Thomson who spoke of the wonderful and rapid growth of the science of electrical engineering and told of many marvellous things which the electrical engineers were dreaming of. One of these was to bring about a current of electricity that could be made to alternate no less than 500,000,000,000,000 times a second, when this was accomplished a perfect electric light would be obtained at a low cost: he also believed that in time all the steam railway locomotives would be superseded by electric motors. He had now an engine that was capable of running 45 miles an hour and even greater speed would be obtained before long. He closed with an account of what had been accomplished in the distribution of power from distant points by electricity.

President Capen spoke of the necessity of broader education among professional men, and Col. Prout, of the future relation of the civil engineer to the railroads.

Dr. Chandler spoke for the astronomer and for the professional man whose work offered so little of apparent practical value.

The other speakers were, Maj. Livermore, Mr. Cabot, Dr. Walcott, and Mr. Manley of the Society.

Annual Meeting. March 16, 1892.—The annual meeting of the Society was held at the Rogers Building, Massachusetts Institute of Technology, Boston at 19:45 o'clock. President Stearns in the chair. Seventy-three members and forty-five visitors present.

The record of the last meeting was read and approved.

Messrs. Percy M. Blake, Norman W. Eayrs and Frank A. Foster were elected members and Mr. Arthur J. Wellington an associate of the Society.

The Secretary submitted the annual report, of the Board of Government, which was read and accepted.

The report of the Secretary was read and accepted.

The Treasurer submitted his annual report, which was read and accepted.

The Secretary read a letter from the Chairman of the Committee on Weights and Measures stating that the Committee had no report to submit this year and Mr. McClintock for the Committee on National Public Works made a similar statement for his Committee.

The Secretary stated that the Committee on Highway Bridges had no report to offer at this time.

Mr. Doane, Chairman of Committee on Permanent Quarters made a verbal report of the work done by that Committee and submitted plans showing a method of remodelling a house in Pemberton Square so that it would meet the wants of the Society for headquarters, and suggested that if the Committee was continued a written report could be presented at an early meeting. On motion of Prof. Allen, it was voted to continue the same Committee. The Committee was also authorized to report in print at a future meeting.

Prof. Porter, for tellers appointed to canvass the letter-ballots for officers, announced the result of the ballot. There being no election for Vice-President by letter-ballot, the meeting proceeded to choose from the two candidates having the highest number of ballots. As the result of the letter-ballot and the choice of the meeting, the following were announced as the officers elected:

President, Henry Manley.
Vice-President, (for two years) Albert F. Noyes.
Secretary, S. Everett Tinkham.
Treasurer, Edward W. Howe.
Librarian, Frank W. Hodgdon.
Director, (for two years) Frederick Brooks.

Mr. Whitney presented the report of the Committee on Excursions, which was read and accepted.

Mr. Hodgdon presented the report of the Committee on the Library which was also read and accepted.

Mr. Freeman moved that the question of continuing the several special committees and the selection of the members thereof, be referred to the Board of Government with full powers. After a short discussion, by Mr. Howland who the opposed motion and desired that the matter be laid on the table till the next meeting, and by Mr. Smith who favored the reference to the Board of Government, the motion was carried.

The Secretary read a communication from Mr. O. Chanute inviting the members of the Society to attend and take part in the Fifth International Congress for Internal Navigation, which is to be held in Paris, beginning July 21, 1892.

A communication was also read from the Secretary of the Massachusetts Commission World's Columbian Exposition asking the co-operation of the Society in securing a creditable exhibit from Massachusetts in the department of civil engineering at the World's Fair. The communication was

referred to the Board of Government to report at a future meeting what action was desirable.

A vote of thanks was passed to the President of the American Bell Telephone Co., for courtesies shown the members on the occasisn of the visit to the new Telephone Building.

The President then introduced Mr. Thomas C. Clarke of New York, who gave a very interesting talk on the progress made in bridge building during the last fifty years, with especial reference to long spans and deep foundations. His remarks were illustrated by a number of lantern views of the Poughkeepsie and the Hawkesbury bridges and of a proposed bridge across the Hudson river at New York.

On motion of Mr. Manley the thanks of the Society were extended to Mr. Clarke for his interesting address.

(Adjourned) S. E. TINKHAM, Secretary.

ANNUAL REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1891-92.

In accordance with the requirements of the Constitution, the Board of Government submits the following as its report for the year ending March 16, 1892:

At the last annual meeting the total membership of the Society was 265, four honorary members, one associate and 260 members. During the past year we have lost four members, two by death and two by resignation, and 29 new members have been added to the list, making a net gain of 25. Messrs. James B. Francis and Samuel Nott, both of whom have been connected with the Society ever since its organization in 1848, have this year been placed on the list of honorary members. The Society at present has a membership of 290, of which 283 are members, six honorary members and one an associate.

It is worthy of note that this year no member has forfeited his membership on account of non-payment of dues.

The Treasurer's report shows a net gain of \$634.01 in the funds of the Society, of which \$445.91 has been added to the permanent fund.

Ten regular meetings and one social gathering have been held during the year.

At the regular meetings the attendance aggregated 553 members and 178 visitors, a total of 731. The smallest attendance at any meeting was 28, and the largest was 99, the average being 73. The attendance at the annual dinner was exactly 100, members and guests.

During the year the following papers and discussions have been given:

March 18, 1891:—Annual Meeting:—Address by President Clemens Herschel: "On the Advancement of the Profession of the Civil Engineer."

April 15, 1891:—Refrigerating Process, Water-supply and Sewerage System of the North Packing & Provision Co., at Somerville, by G. A. Kimball.

Asphalt and Stone Pavements in Buffalo, by H. T. Buttolph.

Discussion on Highway Legislation.

May 20, 1891:—Town Boundary Survey of Massachusetts, by C. H. Van-Orden.

Some Problems in City Engineering, by L. M. Hastings.

Methods used to determine the best capacity to give Basin 6, Boston Water Works, by Desmond FitzGerald.

June 17, 1891:—The Chemical Precipitation of Sewage, by Allen Hazen.

September 16, 1891:—The Selection of Sources of Water Supply, by Pres. F. P. Stearns.

October 21, 1891:—Chignecto Ship Railway, by Dwight Porter.
Account of the International Congress of Hygiene and Demography, by Thomas M. Drown.

November 18, 1891:—Aspects of European Sanitary Science, by W. T. Sedgwick.
New Form of Stadia Telescope, by R. H. Richards.
Stadia Charts, by E. P. Adams.

December 16, 1891:—Memoir of Samuel M. Felton, by a Committee of the Society.
Stony Brook (Boston) and its Improvements, by H. H. Carter.

January 18, 1892:—Series of Papers on Municipal Government in some of the larger cities.
St. Louis, by Robert Moore; Boston, by William Jackson; New York, by Francis M. Scott; Philadelphia, by Dwight Porter; Providence by J. Herbert Shedd; Buffalo, by E. B. Guthrie; Paris, France, by H. D. Woods.

February 17, 1892:—Highway Construction, Discussion by W. E. McClintock, C. R. Cutter, H. B. Wood, Henry Manley and E. W. Howe.
Course of Instruction in Highway Engineering at the Mass. Institute of Technology, by F. E. Foss.

Further announcements have been made during the year with reference to the International Engineering Congress to be held at Chicago in the summer of 1893, in connection with the Columbian Exposition. It is hoped that the members of this Society will do their fair share in promoting the success of this Congress by presenting papers and otherwise taking part in its proceedings. This Society has been called upon to assist in maintaining an engineering headquarters during the continuance of the Exposition, by contributing $550, and its members have shown their interest in the matter by promptly subscribing nearly the full amount. The Treasurer reports that $538.50 have been subscribed, of which $327, have been paid.

The Secretary reports that ten members have subscribed $59, towards the fund for erecting a monument to James B. Eads, of which $29, have been paid and are now in his possession.

Our connection with other local societies in the country by means of the Association of Engineering Societies continues to be entirely satisfactory. There has been one meeting of the Board of Managers of this Association at which our Society was represented. At this meeting it was voted to terminate the contract under which the Journal was then being pubiished and to resume the plan originally adopted of publishing it on the account of the Association, which is now believed to be strong enough to carry it on successfully. This change has resulted in a decided improvement in the general appearance of the Journal.

For the Board of Government.

FREDERIC P. STEARNS, President.

Boston, March, 16, 1892.

ABSTRACT OF THE TREASURER'S AND SECRETARY'S REPORTS FOR THE FINANCIAL YEAR 1891–92.

Current Fund.

Receipts.

Dues of Resident Members for 1891–92, 198 at $6.00	$1188.00
" Non-resident Members for 1891–92, 60 at $4.00	240.00
" " " " " 1	1.25
" Resident " " 1892–93, 2 at $6.00	12.00
" Non-resident " " " 3 at $4.00	12.00
" New Members	134.00
Sales of Journals	1.25
Old Furniture sold	3.33
Interest on Deposits	16.85
Cash at beginning of year	295.64
	$1904.32

Expenditures.

Association of Engineering Societies for Journal	$772.82
" " " " Managers' Meeting	28.72
Binding and periodicals	35.15
Printing, postage and stationery	230.89
Annual dinner	30.00
Expenses of meetings, rent, stenographer and lantern	123.00
Secretary's salary	200.00
Cash on deposit	483.74
	$1904.32

Permanent Fund.

Receipts.

Twenty-nine entrance fees	$290.00
Interest and dividends	155.91
Cash at beginning of year	482.87
Total	$928.78

Schedule of Funds of the Society, March 11, 1892.

One Republican Valley R. R. Bond, par value		$600.00
Nine shares C. B. & Q. R. R., Stock, par value		900.00
Mortgage on real estate		1500.00
Cash on deposit, Permanent Fund	$928.78	
Current Fund	483.74	
		$1412.52
		$4412.52
Schedule presented at last annual meeting		3778.51
Net gain		$ 634.01

The Treasurer has also on deposit $327.00 for Chicago Headquarters Fund.

REPORT OF COMMITTEE ON LIBRARY.

To the Boston Society of Civil Engineers:—

The library has remained during the past year at Room 70 in the American House, but as the room is small and already filled before, the accessions for the past year have been and are now stored at the offices of the Secretary and Librarian.

Nine volumes of periodicals have been bound during the year.

Notwithstanding the chaotic condition in which the library is necessarily owing to the limited space available and also owing to the very limited time which the Librarian can devote to it, it has been used more during the past year by the members than in any other year since it was moved from the Boston & Albany Railroad Station.

During the year the Librarian has been looking to see what could be done to make the library more accessible to the members and has found one member who has a large office room and who thinks an arrangement might be made to have the better portion of the library moved to his office and for a small compensation one of his assistants might care for it. If this could be done the balance could be arranged in Room 70 and there would be sufficient space for the accessions for a few years.

Within a few days it has been brought to the attention of the committee that a number of valuable reports might be obtained now from an estate which is being closed up and the committee are looking the matter up.

The magazines which are received by the Society by exchange or subscriptions are:—

London Engineering, Engineering News, Engineering and Building Record, Annales des Ponts et Chaussees, The Electrician, Railroad Gazette, Railroad and Engineering Journal, Journal of the Franklin Institute.

These together with the Government and other reports and transactions of other societies, form the only means of increasing the library.

Respectfully submitted,

F. W. Hodgdon, Librarian.
S. E. Tinkham,
H. D. Woods,
X. H. Goodnough,
Committee on Library.

Report of Committee on Excursions.

To the Boston Society of Civil Engineers:—

The Committee on Excursions submit the following report of their work for 1891-92. The excursions arranged were:—

April 15, 1891:—North Packing & Provision Co., Somerville, 50 present.
May 20, 1891:—Basin 6, Boston Water Works, Ashland, 53 present.
June 17, 1891:—Lowell Carpet Works and Merrimack Mills, Lowell, 43 present.
Oct. 21, 1891:—Metropolitan Sewerage Works, Deer Island, 46 present.
Nov. 18, 1891:—West End Street Railway's Power Station, Albany street, Boston. 46 present
Dec. 16, 1891:—Mystic Wharves, 16 present.
March 15, 1892:—New Building of American Bell Telephone Co., Milk Street, Boston, 34 present.

The only comment or suggestion the committee have to make is in relation to the annual excursions. There seemed to be a general lack of interest in the matter last year and the committee would recommend that their successors make sure that the members wish to continue the custom before making arrangements for another excursion.

For the Committee.

Boston, March 15, 1892. F. O. Whitney, Chairman.

THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

MARCH 8, 1892:—The twelfth Annual Meeting was called to order by President Gobeille at 8 o'clock P. M. with 34 members and visitors present. The minutes of the last meeting were read and approved.

The President appointed Messrs. Wm T. Blunt and C. O. Palmer as tellers to canvass the ballots for the election of new members and for the election of officers for the ensuing year.

The executive Board recommended the election of Messrs. Ernest Charles Barth and Peter Rasch as active members.

A communication from Mr. O. Chanute regarding the Fifth International Convention for Internal Navigation to be held at Paris in 1892 was read by the Secretary.

Mr. C. P. Leland, chairman of the banquet committee, reported that arrangements had been made for holding the Annual Banquet at the Hollenden on March 15th and that the attendance promised to be larger than at any previous banquet.

The Secretary, Treasurer, and Librarian presented their annual reports, which were accepted.

Motion was made and carried that the Treasurer reimburse the President for money expended for Club stationery, work on the certificates etc. amounting to $55.40.

On motion it was voted that Mr. C. P. Leland be appointed to examine the vouchers of the Treasurer.

Mr. Morse, chairman of the programme committee, reported on the work of the year. The programme committee presented three short but interesting reports, one by Prof. D. C. Miller read by Prof. Howe on "Progress of Astronomy in 1891," one by Mr. Mordecai on "Railroad Engineering" and one by Mr. Coburn on "Recent Works of Architecture".

The tellers reported that Messrs. Sidney R. Badgley and Peter Neff Jr., had been elected active members, and that Mr. Edwin L. Thurston had been elected an associate member.

They also reported that the following officers had been elected for the ensuing year:

For President, Walter P. Rice.

For Vice President, Albert H. Porter.

For Secretary, Charles S. Howe.

For Treasurer, Cyrus P. Leland.

For Librarian. Charles H. Benjamin.

For 1st Director, Charles H. Strong.

For 2nd Director, Gustavus A. Hyde.

A vote of thanks was tendered the retiring officers.

The Annual Address was delivered by retiring President Gobeille on "The Financial Status of the Engineer."

On motion adjourned. A. H. PORTER, Secretary.

SECRETARY'S REPORT.

To the President and Members of The Civil Engineers' Club of Cleveland.

GENTLEMEN: The records of the Club show the following as the results of the last years work: Ten regular meetings besides the Annual Meeting were held during the past year, the meeting for August only being omitted. At these meetings the total attendance of members and vis-

itors was three hundred and fifty-four or an average attendance for the ten meetings of thirty-five. The largest number present at any meeting was on June 12th when sixty members and visitors were present. The smallest attendance was on Sept. 8th when only twenty members and visitors were present.

Besides the regular meetings there was the Annual Banquet on March 17th which about one hundred and sixty-five members and guests attended, the annual picnic on July 11th at which about seventy-five members and friends were present, a visiting day on September 29th when thirty-seven members and friends were present, and another visiting day on November 10th when eighty members and friends were present.

President Gobeille was present and presided at every meeting during the year.

There have been read before the Club since the last Annual Meeting *thirteen* papers, not counting those at the Annual Meeting, besides six interesting reports on technical subjects, some of which were equivalent to short papers.

The papers were as follows:

The Education of the Mechanical Engineer, Prof. C. H. Benjamin.

Recent Advancement in Electrical Engineering, James Ritchie.

Considerations Governing the Choice of a Dynamo, E. P. Roberts.

Steering Gear on Vessels for Lake Service, Walter Miller.

Design for Store Fronts of Sixty Feet Span without Intermediate Supporting Columns, James Ritchie.

Straw and Corn on the Cob as Fuel for Domestic Purposes, Jos. Leon Gobeille.

The Lamp, The Electric Light Station Manager and the Customer, E. P. Roberts.

A New Method of Computing Areas in Land Surveying, Prof. C. S. Howe.

French Roads, Their Administration, Construction and Maintenance Prof. F. H. Neff.

Mathematical Tables and Methods of Computation, Prof. C. S. Howe.

The Patent Office of The United States, N. P. Bowler.

On the Center of All the Dry Land on the Earth's Surface, Prof. J. N. Stockwell.

Mining Engineering, John L. Culley.

The membership at the commencement of the year consisted of four Honorary, five Corresponding, eight Associate and one hundred and thirty-six Active Members,—a total of one hundred and fifty-three. Our membership has not been reduced by a single death during the year. One Active member, Mr. J. F. Holloway, has been elected an Honorary member. Three Active members have been transferred to Corresponding members, and one Corresponding member, Mr. Wm T. Blunt, has taken up his residence among us and resumed his Active membership. Two Active members Mr. F. W. Wilson and Mr. E. H. Martin have resigned. One Corresponding and eleven Active members have been elected, so that the membership now consists of five Honorary, eight Corresponding, eight Associate and one hundred and forty-one Active members, a total of one hundred and sixty-two.

Early in the year the subject of incorporation was brought up and discussed, and finally the Executive Board was instructed to secure the incorporation of the Club. This was at once done and late in May the cer-

tificate of incorporation was obtained, framed and hung in the Club rooms.

Certificates of membership have been engraved, printed, filled in and forwarded to every member whose name and address could be obtained.

The provisions of the new constitution which was adopted at the last Annual Meeting necessitated a considerable increase in the expenses for printing with no increase in the income for the year just closed. The sum placed to the credit of the *permanent fund*, and the amount advanced towards the Clubs' share of the expenses of the Columbian International Congress and Engineering Headquarters, leaves the amount in the hands of the Treasurer small, still it is probable that the increased dues for the current year, and the increase in the *permanent fund* will place the finances of the Club in a better condition than ever before.

Respectfully submitted,

A. H PORTER, Secretary.

REPORT OF THE LIBRARIAN.

During the past year the work of the librarian has not been a matter of very serious consequence, he has not glorified himself by burning the midnight oil of his vital energy in long weary hours of toil for the library. In spite, however, of this drawback, the library has grown and prospered.

At one of the very first meetings of the Civil Engineer's Club provision was made for a library. For a period it was, so to speak, embryonic, but donations of books were made by our first president, Chas. Paine, and several others. Many government reports have been received, mostly through the kind offices of Col. J .M. Wilson. Additions have also come from other societies, firms and individuals at home and abroad. We also have a number of pictures, a few specimens of ore and manufactured iron and several valuable articles from the International Society for the Preservation of Weights and Measures, and so on, until we have a collection of appreciable value.

The location of our quarters in Case Library was the commencement of the second period of our history. The arrangements growing out of this relation have been of great *value* to the club. During the years that followed, we have had a pleasant room, it has been well taken care of and every convenience that could be practically provided in a room of this size has been ours to enjoy. For very much we are indebted to the uniform kindness of the Trustees of Case Library.

It is proper to state that between this club and the Case Library there has grown up gradually a relationship which has developed into a mutual interest and kindly feeling. Of course, this cannot but result in benefit to the Club, and we trust that the Civil Engineer's Club by its high standing as a scientific organization, by the scholarly attainments of its membership and by the strength of its moral influence and position in the City of Cleveland will be a strong support for Case Library.

As a well selected collection of choice books the Case Library is without doubt the finest library in the State and this is especially true from a scientific stand-point.

For the first thirty years of its life it was supported principally by membership fees. In 1862 it was given its pleasant rooms free of rent and in 1876 Mr. Leonard Case, Jr., gave the Cleveland Library Association the entire Case Block, valued then at \$300,000 and the name was changed to the Case Library.

The Library itself is worth nearly or quite $100,000.

Let us look for a moment upon these shelves which have been the pride of our growing City for forty-seven years. Crowded within these walls are thirty thousand volumes, exclusive of Government Reports. On the tables and files are 157 monthly, weekly and daily journals.

If you are interested in Ornithology, here is Audubon's Birds of America, valued at $400, besides all the other great standard works on this subject. If you are interested in Botany, you will find Lardon's "Arboratum," Sargent's "Silvia of North America," (which is gotten up on the grandest scale of any book ever published in this or any other country) and beside every other noted book on Botany.

On Zoology, we will find beside many others the reports of the voyage of H. M. S. Challenger Around the World for Deep-Sea Soundings, worth $300. For the artist who is interested in Ceramic Art here is a beautifully illustrated work, "The Ornamental Arts of Japan" in two volumes, valued at $110 and the Soft Porcelain of France, a most beautiful volume.

The Library contains all the Dictionaries and Cyclopedias of Science, Art or Literature of known value that are published. In fact, a more complete reference library would be difficult to find. For Inventors there are the full and complete Patent Office Reports, Drawings and Specifications to date, and every work on Patent Laws. Here are splendid works on Ship-Building, and as for text-books, the departments of Civil Engineering, Architecture, Electricity and Chemistry are all exhaustively represented.

New and late books are daily being added which are selected not with reference to their expense but to their value as standard works. One of the recently added volumes is Rowland's Photographic Map of the Spectrum. Prof. Rowland is an American Civil Engineer; his great work on this subject surpasses in correctness, exhaustiveness and practical value any work on this subject ever published.

Of course, it is well known to the members of the Club that any book of known value not in the Library that is desired by any member of this Club will be purchased and added to the Library if the Librarian is notified. The members of the Civil Engineer's Club are also cordially invited to use the Reference Books freely and to take them to their homes if they desire (the term Reference Books refers to those books that are regarded as too valuable to be placed in general circulation).

To the Librarian, Mr. Orr, we are indebted for many kind courtesies. Mr. Orr is an experienced librarian thoroughly conversant with books in general and with the biblical wants of Engineers. I would especially recommend the members of the Club to become acquainted with Mr. Orr.

For all the purposes for which our members could want a library the Case Library is as completely open to their use as if the words, The Civil Engineer's Club of Cleveland, were written over the outside doors of Case Block.

This great Library has, like the Civil Engineer's Club, outgrown its quarters. The rooms have been enlarged until it is now necessary to make extensive alterations in this building or build another. The Board of Trustees have decided upon the latter course, and I am authorized to state what many already know, that in the new building, large and convenient rooms are to be provided for the Civil Engineer's Club.

The new building will be very near this one, having a front of fifty feet on Rockwell St. and extending 125 feet on Park Place. It is contem-

plated to reserve for us fifty feet, square on the lower floor. The building will be commenced early this Spring and will be pushed rapidly to completion.

In regard to the books and pamphlets that are the private property of the Club, an arrangement has been made whereby they will be placed under the care of the Case Library, where they will be catalogued, numbered and otherwise cared for. They will be kept together and in the Club Room, and will be taken from the Library only by members of the Club, and are insured against fire.

The work of the incoming Librarian will not be less arduous than that of his predecessor. The rubber stamp still remains, the signet of the office, and I leave it to him and those that may follow him, to mark in analine colors on the clean first page of every new book, "The Civil Engineer's Club of Cleveland".

Respectfully submitted,
CLARENCE M. BARBER, Librarian.

WESTERN SOCIETY OF ENGINEERS.

290th MEETING. APRIL 6TH., 1892:—The 290th meeting of the Society was held at Apollo Hall, Central Music Hall Building, Wednesday April 6th., 1892, at 8 p. m., President Randolph in the chair and over 100 members and guests present.

The minutes of the last meeting being formally approved, the Secretary reported for the Board of Directors the following members elected:

James R. Smedberg, T. N. Conlin, Wm. Shingleton, George Weston, Fredk. H. Davies, James D. Raynolds, Robert E. Orr, Chas. N. Roberts, William C. Halliday.

The following applications were received:

Garrett Davis, John C. Spencer, Herbert F. Northrup, James F. Deimling.

The Committee on Permanent and Temporary Quarters submitted a progress Report.

President Randolph briefly called attention to the special work of the evening and asked for a motion to suspend the regular order of business. Moved and seconded that the regular order of business be suspended. The President then explained the object of the meeting to be to discuss the question of a Technological School in connection with the University of Chicago, and concluded by introducing Prof. Harper, who spoke at length on the subject, detailing the position the University would take and what it would do for the cause.

Prof. Harper was followed by Mr. Willard A. Smith, Chief of Transportation Exhibits, Columbian Exposition, Mr. D. Adler, Mr. Francis W. Parker, Mr. L. P. Morehouse, Mr. L. E. Cooley, Mr. H. L. Bridgman, Mr. T. G. Gribble, and Mr. Perry. A vote of thanks was tendered to Dr. Harper.

Adjourned. JOHN W. WESTON, Secretary.

MAY 11TH., 1892. The 291st. meeting of the Society was held at the rooms of the "Central Traffic Association," The Rookery, Chicago, Wednesday evening, May 11th., 1892, with over 60 members present. President Isham Randolph in the chair.

The minutes of the preceding meeting were approved.

The Secretary reported the following new members elected: Garrett Davis, John C. Spencer, James F. Deimling, Herbert F. Northrup.

The application of Mr. John R. Darcy was filed.

The report of the Committee on the "Railway Problem of Chicago" etc., being in order, President Randolph rose to explain, on behalf of the chairman of the Committee, Mr. Richard P. Morgan, and himself, the delay in the presentation of this Report. Mr. Morgan's absence in California had interposed difficulties in the way of communication which had seemed to impose upon the president of the Society, the necessity, endorsed by the other members of the Committee, of presenting the Report without a final word from the Chairman of the Committee. Mr. Morgan had made great sacrifices, both of time and money, and had been indefatigable in his efforts to carry on the work of the Committee.

The Report of the Committee was read by the Secretary. On the conclusion of the reading President Randolph stated that this was the majority report, and that there would be two and possibly three minority reports, which should properly be presented together, he would therefore ask for instructions.

MR. CORTHELL: I move that the majority report of the committee which has been read, and any minority reports that there may be, be printed as soon as possible and distributed to all the members of the Society for reading and study and at the next meeting of the Society, the subject be discussed. Seconded and carried.

MR. THOS. APPLETON then presented the following resolution:

Resolved:—That a committee consisting of the Board of Directors and three members to be appointed by the chair, take up and consider the matter of amenments to the Constitution and By-Laws, said committee to report to the Society as soon as practicable, with drafts of such amendments as they recommend. And all members of the Society are invited to send to the Secretary any suggestions relative to revision of the Constitution and By-Laws which may seem to them advisable, and such suggestions will be duly considered by said Committee. Seconded and carried.

Adjourned. JOHN W. WESTON, Secretary.

Editors reprinting articles from this journal are requested to credit both the JOURNAL *and the Society before which such articles were read.*

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. XI. June, 1892. No. 6.

SMOKE PREVENTION.

REPORT OF THE SPECIAL COMMITTEE ON PREVENTION OF SMOKE.

[Presented to Engineers' Club of St. Louis.]

Your committee, charged with the duty of investigating the coal smoke problem, and making such recommendations as may tend to abate the evil which prevails in our city to so serious an extent, offer the following report as the result of a careful consideration of evidence accumulated not merely during the past year of this committee's existence but through many years, as well, of active interest in the various questions relating to the economical use of fuels.

The subject will be discussed under the following general heads:

I. Introduction. Importance of the Subject to all Classes of the Community. Misapprehension existing as to the Nature of the Problem.

II. The Principles and Reactions upon which Combustion depends. Conditions favorable for Producing Smoke and those required to Prevent.

III. The Fuels used in St. Louis and their Relation to the Smoke Problem.

IV. The Various Classes of Fuel Users and their Relation to the Smoke Problem.

V. Conditions of Fuel Consumption under Boilers in St. Louis.

VI. Requirements Necessary for a Satisfactory Smoke Preventing Device.

VII. Classification of the Important Types of Smoke Preventing Devices and the Principles upon which they Depend.

VIII. Experience in Other Cities relating to the Abatement of the Smoke Nuisance.

IX. Conclusions and Recommendations.

INTRODUCTION.

It may be said that St. Louis has suffered more than any other important city of the country from a combination of three conditions most unfavorable to the improvement and metropolitan development of any community, 1st. unpaved or badly paved streets, 2nd. water, if not unwholesome, at least unattractive and often repulsive in appearance, and 3rd. an atmosphere polluted with coal smoke. Happily for this community the most serious of these handicaps has been removed and St. Louis may now claim to be one of the well paved cities of the country. The benefits of this improvement are so remarkable and so widely recognized that few among us will deny the beginning of a new era of development and prosperity with the establishment of good pavements. The work of installing the main low service pumping plant at Chain of Rocks, far above the sources of pollution from city and suburban drainage is already well advanced. This change and the many improvements connected with it (some the results of investigations now in progress with a view to removing the mechanical sediment and improving the quality of the water) will ere long give to the people of St. Louis a better service, and a water not only purer and more wholesome but unobjectionable in appearance. There will remain then the purification of the atmosphere by the proper abatement of the smoke nuisance. With this secured not only may St. Louis boast of conditions upon which especially depend outward attraction and the comforts of living, but the community with the intelligence and energy to accomplish reforms such as these will be sought after as one possessed of the best elements of prosperity and progressive development.

Of the three great problems referred to relating to the material improvement of the city that which seems to interest the greater number of people and call for the more general comment and criticism is the smoke problem and yet it is, apparently, the one least understood. In its relation to this problem the community may be divided into three general classes viz., the manufacturers and other large consumers of bituminous coal: the inventors and promoters of smoke preventing devices, and the general public. The manufacturers and other large coal users are mainly responsible for the production of the smoke. They may or may not have had experience with smoke preventing devices. If they have, they are as a rule dissappointed because of the failure to secure benefits recklessly promised. General indifference results, or an established belief that there is no satisfactory solution to the problem. The inventors and promoters of these devices stand

ready with their universal solvents unable to understand why their efforts for the public good are so little appreciated. Their patent appliances are unsuccessful in some cases because of being founded upon an entire misconception of the underlying principles and reactions involved in the combustion of bituminous coal, or, in others, from a want of appreciation on the part of the inventors and users alike, of the conditions which fix the limitations of successful application. And lastly the general public, too ready to assume that a smoking chimney represents wasteful combustion of fuel, inveighs on the one hand against the recklessness and want of enterprise in the manufacturers who continue to pullute the air and on the other against inventors and even engineers and men of science for their indifference or want of skill while a problem which promises such rich rewards remains unsolved.

It would seem, then, that as in the case of so many other questions of public concern, the whole community must be educated to a more intelligent understanding of the problem before a satisfactory solution can be successfully brought about. In view of this your committee deem it important to present at the outset a brief but clear statement of the reactions involved in the combustion of bituminous coal and their relation to the development and prevention of smoke.

II. The Principles and Reactions Upon Which Combustion Depends. Conditions Favorable for Producing Smoke and Those Required to Prevent.

All coals are composed of an organic part which is a complex chemical combination of carbon, hydrogen, oxygen and nitrogen and an inorganic, or mineral part, known as ash, consisting in the main of clay and minor quantities of iron and other impurities. Of the organic matters carbon forms by far the larger part and nitrogen is present usually to the extent of not more than one, or one and a half per cent.

Under a sufficiently elevated temperature carbon and hydrogen combine readily with the oxygen of the air thereby producing sensible heat. The nitrogen is inert and merely plays the part of a diluent, while the oxygen in chemical combination with the other elements of the organic matter represents useful material already oxidized and therefor used up. When decomposition of the organic matter is effected by the application of heat any two of the elements such as carbon and hydrogen or hydrogen and oxygen may separate from the general compound but heat is not developed because no chemical combination has taken place, but on the other hand heat is absorbed because a separation of these elements from the general combination has occurred.

Besides the elements already referred to sulphur will be found to some extent in all coals and the greater part of this is usually present

in combination with iron in the form of a distinct mineral of brassy yellow color, known as pyrites, which occurs mechanically associated with the coal.

More or less moisture is always present in coal. When excessive this may be due to mine water or exposure to rain or snow after the shipment from the mine. Much of this moisture escapes on air drying but there always remains even after long air drying or in what appears to be perfectfy dry coal, a notable quantity of moisture which in the ordinary bituminous coals coming to this market ranges from 5 to 10 per cent. This moisture can only be removed by exposing the coal to a temperature of at least 212 degrees F.

The mineral matter or ash may include not only what might be called essential ash, that is, the mineral matter taken up by and forming a part of the plants from which the coal is derived, but may include also other and extraneous matter generally in the form of clay shale or slate occurring along the planes of lamination of the coal. The slaty material can to some extent be removed by hand picking and very thoroughly by crushing and washing the coal, but the essential ash, which, however, is small in quantity and less injurious, must remain with the coal until the organic part is burned away.

During combustion the particles of coal are more or less protected from exposure to the air and the grate bars become clogged by the ash, rendering combustion slow and irregular, while heating power is to some extent sacrificed in heating this inert matter. In these respects the evil increases with the *quantity* of ash. The fusibility, which depends upon the *quality* of the ash, is even more serious in its effects during the process of combustion. Oxide of iron if present in any considerable quantity would, by the formation of more fusible slags, increase the evil. Oxide of iron is derived mainly from the pyrites which loses its sulphur during the combustion of the coal leaving the iron to oxidize and combine with the silicious clayey matter. Not only is a very fusible slag thus easily formed but one that makes a very hard and clinging clinker.

Turning now to the process of combustion it will be seen that when the coal is first charged into the already heated fire place the moisture and other volatile matter readily pass off leaving each lump of coal an incandescent mass of coke from which finally the glowing carbon is removed by oxidation and the mineral matter or ash alone remains. This process, simple as it at first appears, is really very complex. The moisture which may be evaporated at so low a temperature as 212 degrees F. does not necessarily pass off at once in the highly heated fire place before the other volatile matter is set free. The decomposition begins immediately on the outside of the lumps of coal and the volatile matter, and the moisture from adjacent parts, escape

together. Owing to the poor conducting power of the coal the heat travels but slowly to the interior of the lumps, so that for a considerable length of time after the coal has been charged it is giving off moisture with the combustible volatile matter and thus diminishing the temperature of combustion. When this moisture is present in very large amount as in lignite coals, containing from 12 to 20 per cent. its rapid escape induces a slacking of the coal which gives rise to serious loss from packing on the grate bars and the sifting of fine coal through the bars. That which is known as volatile matter is set free and escapes in the gaseous form as soon as decomposition of the coal is effected by the heat. The temperature at which this decomposition takes place varies with different kinds of coal. For bituminous coals it generally begins at about 250 degrees F. but of course is very slow at such a low temperature. The rate, also, at which the volatile matter is given off at any definite high temperature varies somewhat with different coals as may be seen when treating coals in gas retorts.

The composition of the volatile matter is very complex but it consists essentially of combined water and the hydrocarbons. The combined water is produced by the oxygen, which forms parts of the chemical combination of the organic matter of the coal, passing off with one-eighth of its weight of the hydrogen present. This, as before stated, does not represent oxidation performed during the combustion but simply elimination of the two, in these proportions, from the original organic compound. Heat is absorbed in this elimination and a further quantity of heat is sacrificed to raise this vaporized water as well as the moisture of the coal to the temperature of the furnace.

The term hydrocarbon is applied to the complicated series of organic compounds set free during decomposition. For present purposes these may be divided into three series which are clearly to be recognized while decomposition is in progress, whether brought about in closed retort or open fire place. These are: the light hydrocarbon or marsh gas series (CH_4) with three parts of carbon by weight to one of hydrogen: the heavy hydrocarbon or olefiant series (C_2H_4) with six parts of carbon to one of hydrogen; and the asphalt or bitumen series which is too complicated to receive any definite formula but which contains still more carbon in proportion than in the olefiant series and also more or less oxygen. The marsh gas and olefiant series are gaseous forms of hydrocarbon, and the asphalt or bitumen the solid form which is more or less easily melted as the proportion of hydrogen is greater or less.

Although called bituminous this class of coals contains no bitumen. When decomposition takes place, however, under heat, compounds of the bituminous or asphaltic series are formed. The combined oxygen and one-eighth of its weight of hydrogen are set free as

the combined water while the remaining or available hydrogen in combination with more or less carbon forms the hydrocarbon series.

The light and the heavy gaseous hydrocarbons volatilize in varying proportions according to the composition of the coal. The light hydrocarbon burns with a pale non-luminous flame and with a maximum effect of 23,500 heat units. Dissociation or separation of the hydrogen and carbon from combination with each other does not readily take place in this hydrocarbon and the products of its complete combustion are carbonic acid (CO_2) and water (H_2O).*

The heavy hydrocarbon is easily affected by heat and dissociation occurs at a red heat resulting in half of the carbon being set free leaving the gas as light hydrocarbon ($C_2H_4=C+CH_4$). It is this separated carbon in an incandescent state which in the main causes the luminosity of the flame when the heavy hydrocarbon is burned and it is *this same separated carbon which makes the visible smoke when bituminous coal is burned.* For the rapid combustion of this separated carbon not only is a strong oxidizing action necessary but a very high temperature as well, probably not less than 2,000 degrees F. If this high temperature is not supplied in the fire place, where the gases are generated and the carbon separated, the latter will be carried along by the rapid draught and pass out unchanged as visible smoke.

The conditions which ordinarily prevail when this carbon is separated are, it must be seen, quite unfavorable for its combustion. The coal is thrown into the fire place in cold lumps and generally in excessive quantities thereby interposing a comparatively cold and poor conducting layer between the glowing coals below and the gases rising from the fresh coal. Moreover while these hydrocarbon gases are being set free the moisture and the combined water, together amounting to from 10 to 20 per cent. of the whole weight of the coal, are passing off and absorbing a large quantity of the heat produced. The high temperature required for the combustion of the separating carbon is therefore under these usual conditions impossible to attain. The quantity of air, too, which should at this stage of the operation be higher than at any other is either very much less, owing to the thicker bed of fuel on the grate, or if introduced above the grate, most commonly enters directly through the firing door and is of low temperature. The heat, already comparatively low, is further reduced by this great volume of cold air, which having but little opportunity to mix with the gases, performs but imperfectly the duty for which it is admitted. Cold air

*The term "Heat Unit"—H. U. also called "British Thermal Unit"—B. T. U. is the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit. To evaporate one pound of water of a temperature of 212 degrees F. into steam of the same temperature requires nearly 966 H. U.

and heated gases do not readily mix and the combustion of gases under such conditions is very imperfect. It is not surprising that under such conditions as these, much of the combustible gas reaches the chimney unburned and it is much less to be expected that any of the separated carbon should be consumed.

Bitumen may be developed to such an extent during the combustion of some kinds of bituminous coals as to exude from the lumps, causing them to stick together and, as the heavy gaseous hydrocarbons are gradually distilled from this tarry asphalt a pitch coke remains firmly cementing the lumps and small fragments of coal into one large cake. This property of the "caking coals" adds to the evils already described. The grate becomes quickly clogged so that but little air can pass through, necessitating the frequent opening of the firing door and the use of a bar to break up the caked mass. Excessive quantities of cold air rush in and the cloud of smoke from the chimney top appears, if possible, more dense than before.

The coloring capacity of finely divided separated carbon is remarkably great, especially in the case of coals, which like most of our western coals, yield in combustion large amounts of vapor of water from the high percentages of moisture contained and of combined water developed in combustion. That this carbon even from dense smoke represents but a small percentage of the weight of the coal may be shown by chemical examination. More direct proof has been furnished by the experiment of Mr. J. C. Hoadley, C. E., who passed through water all the gases from the flue of a boiler fired with bituminous coal producing a very black smoke, carefully collecting all the solid matter, drying and weighing. The amount of coal burned was 12890 lbs., or about 6¼ tons, every pound of which generated 25.23 lbs., of gases. The total weight of these gases was, therefore, 325215 lbs., or by volume 4263119 cubic feet. The whole quantity of solid matter contained in this bulk of smoke gases was 42.63 lbs., or one-third of one per cent. No analysis was made of the solid residuum collected but its gray color indicated that not more than half of it was carbon. From this it appears that the separated carbon, which made the smoke visible as a dense black cloud, *represented only about one-sixth of one per cent. of the weight of the coal used.*

When coal is heated in a closed vessel or retort the moisture, combined water and hydrocarbons, being volatile, are driven off, but although heated to an intense white heat, if no air is admitted, there will remain the greater part of the total carbon. This part of the carbon is consequently designated "fixed carbon" and with the mineral matter of the coal constitutes what is called "coke". A similar reaction takes place in the process of combustion in a fire place, except that air being admitted, more or less of the fixed carbon is oxidized

and passes off with the volatile matter in the gaseous form as carbon monoxide (CO) if one part of oxygen is taken up to one of carbon, and as carbon dioxide (CO_2) if two parts of oxygen are taken up and the oxidation is thus complete. Lumps of coal may show, therefore, an exterior covering of coke, constantly increasing in thickness, in which the fixed carbon is burning with characteristic glow, while from the cracks and openings streams of the volatile gases are issuing giving a luminous flame terminating in streamers of smoke due to separated carbon.

With the ordinary arrangements for admitting air to a fire place the conditions just described would add somewhat to the difficulties of securing complete combustion. The carbon dioxide gas (CO_2), resulting from the combustion of the fixed carbon surrounding the lumps, would rise and tend to envelope the hydrocarbon gases, escaping from the interior, thus preventing sufficient access of air. Not only this, but the presence of carbon dioxide gas requires that more air be supplied to burn a given quantity of combustible than would otherwise be necessary.

The bed of coke, which in time results after the elimination of the volatile matter, gives up its fixed carbon to complete combustion by means of two reactions. The air admitted at the grate gives up its oxygen, carbon dioxide gas (CO_2) is formed in the lower layers of coke and this is more or less decomposed according to the thickness of the bed, into carbon monoxide ($CO_2 + C = 2CO$). This carbon monoxide, meeting air admitted above the fuel bed, is burned again to carbon dioxide ($CO + O = CO_2$). In practice these reactions are but imperfectly carried out. No matter how thin the layer of fuel on the grate, provided the latter is completely covered, more or less carbon monoxide (CO) will be found to have passed above the bed. This is due to the fact that some of the carbon dioxide (CO_2) formed at first is almost immediately reduced by contact with glowing carbon although there may be on the whole a large excess of air. The proportion of carbon monoxide (CO) increases and that of unconsumed air decreases with the thickness and compactness of the bed.

The reduction of carbon monoxide (CO) is accompanied with a notable absorption of heat. With each unit of carbon monoxide (CO) so reduced 4325 units of heat are absorbed, or the carbon dioxide (CO_2) generated by each unit of carbon if all reduced to carbon monoxide (CO), will cause the loss of 10093 out of 14544 units of heat. If this heat is not recovered by the burning of the carbon monoxide (CO) back again to carbon dioxide (CO_2) above the fuel bed it is evident that less than one-third of the heat available will be utilized.

In review of the facts presented it will be seen that for the complete combustion of bituminous coal including the separated carbon

which forms the visible smoke, it is necessary that a very high temperature be constantly maintained in the fire place and that the air introduced for the combustion of the gases and free carbon above the fuel bed be in sufficient quantity, heated, and intimately mixed with the gases. It will also appear that the fire place ordinarily employed and especially when the fire is worked by the method so commonly practiced, the conditions just mentioned are rarely attained.

III. The Fuels Used in St. Louis and Their Relations to the Smoke Problem.

The fuels employed for various purposes in St. Louis and approximate estimates of their consumption in 1891 are as follows:

A.	Illinois Bituminous Coal,	2142126 tons.
	Pittsburgh Bituminous Coal,	56000 "
B.	Anthracite,	60000 "
C.	Coke, Gas House*	36000 "
	Other Coke *Received* part of which shipped beyond. Balance used in Smelting Furnaces, Foundry, Cupolas, etc.,	165000 "
D.	Gas,	50000000 cu. ft.
E.	Oil.	

A. Bituminous coal is used to a far greater extent than any other fuel, because of its comparative cheapness. The greater part of the State of Illinois is underlaid by workable seams of this coal and the coal producing area reaches within about eight miles of St. Louis. These coal seams lie comparatively near the surface, are quite undisturbed while the overlying rocks make a good roof to work under and contain usually but little water. Mining can therefore be carried on at a low cost and owing to the open and generally level surface which characterizes Illinois, railroads are readily constructed and many of these traverse the coal regions and center here; all of which conditions favor competition in the production of coal and in its transportation to this market.

It will be sufficient for the present discussion to classify the bituminous coal from the area referred to as common Illinois coal, and coal from special districts, such as the Big Muddy, and other districts. The common Illinois coal comes for the most part from mines nearer the city. It is supplied at lower cost and is at the same time of infe-

*The gas house coke here mentioned being a product of the Pittsburg coal is necessarily contained in same: it represents very nearly the amount of fuel available for general use in the quantity of Pittsburg coal in the table of coal receipts. The balance being gas made out of same, tar and other by-products, and the losses in the processes of manufacture.

rior quality, being characterized by large percentages of moisture, ash and sulphur, comparatively low fixed carbon and large proportion of volatile matter, which latter, also, contains much combined water. The heating power is, therefore, not high, usually about 10,000 heat units by calorimeter test, or a theoretical evaporating power from and at 212 degrees F., of about 10½ lbs. of water. The large amounts of moisture and combined water to be vaporized and heated to the temperature of the fire place cause a great absorption of heat and the large addition of waste gases from these sources leads to increased losses of heat carried off by the chimney gases. The tendency to coke somewhat during combustion makes it necessary to open the firing door often to loosen the bed of coal, while the large proportion of iron pyrites present readily causes the formation of hard clinker calling for frequent cleaning of the fire. For these reasons it will readily be understood that the efficiency, that is, the percentage of the theoretical evaporating power utilized in practice, is not large. It is not too much to say that in the average boiler practice of this city the efficiency is considerably less than fifty per cent. This low efficiency is largely due to inferior boiler plants and reckless firing, but to the quality of the coal, outlined above, much is still chargeable. All these causes of low efficiency are very favorable to the development of smoky chimneys, as has been already explained, and the common Illinois coal may be regarded as the chief source of smoke in our city.

Between the class of coal just described and the best type from Illinois, the Big Muddy, there are many grades and in so far as they have less of the objectionable and more of the favorable features, given above, the theoretical evaporating power is higher and the efficiency under similar conditions improved. The Big Muddy is a strong non-caking coal, rich in fixed carbon and comparatively low in moisture, ash and iron pyrites; the volatile matter contains but a moderate amount of combined water and is rich in gaseous hydrocarbons while but little of the asphaltic series is developod in combustion. The calorific value of this coal is about 12,000 heat units with a theoretical evaporation of about 12½ lbs. of water and at 212 degrees F. and the efficiency in good boiler plants should be 65%. It burns with a strong flame and although when carelessly fired or crowded into the fire place it yields richly in smoke, its characteristics are such that it can be made to show with proper handling as good a smoke record as any true bituminous coal.

A small amount of block coal comes to this city from Indiana. This has the same general characteristics as the Big Muddy coal but in a somewhat higher degree and is a favorable coal for yielding a good record if handled with care and skill.

B. Anthracite or, as it is sometimes called "hard coal" is too

high priced in this market on account of the long haul from Eastern Pennsylvania, to be used for ordinary industrial purposes like boiler firing. Its main application is in heating furnaces, ranges, base burner stoves and to some extent in grates in domestic establishments. Owing to the fact that anthracite is mainly composed of fixed carbon with but an insignificant amount of volatile matter and that yielding no heavy hydrocarbons from which sooty carbon can be set free, it burns with but little flame and this is altogether smokeless. To the extent, therefore that this class of coal is used in any city the atmosphere will be free from smoke. It is noticeable in New York, Boston and other eastern cities that formerly, when but little other fuel than anthracite was used, the atmosphere was clear and unobjectionable. In these days, however, with improved facilities for transporting to these cities the more distant bituminous coals, an increasing proportion of the latter is used and complaints of the growing smoke nuisance are more frequently heard.

C. Coke is not only a smokeless but an almost flameless fuel since it is the residuum obtained by distilling off the volatile matter from bituminous coal. It is used to some extent in certain industrial operations and might be employed to advantage for domestic purposes, if it was sold at prices properly proportioned to its fuel value. Gas house coke is porous and bulky, weighing less than half as much per bushel (36 lbs.) as bituminous coal and yet it is sold at a much higher rate (10–11cents) per bushel than coal. For these reasons it cannot be used for boiler and general industrial purposes and in other respects it is not well adapted.

The coke brought to the city from a distance (mainly Pittsburg and the Connelsville district of Pa.) is a much harder and more compact coke than gas house coke. It is made in ovens constructed for the purpose and has been deprived almost entirely of the volatile matter so that it consists only of fixed carbon and ash. For these reasons it is less readily combustible than the more porous and bulky as well as less thoroughly coked gas house coke. The heating power is, however, much higher and it constitutes an admirable fuel for smelting ores, melting metals and other purposes where a strong concentrated heat is required. This coke, costing $1.90 per ton at the ovens, is delivered here at a freight rate of $3.35 making the coke cost $5.25 per ton, while for gas house coke we are charged in St. Louis $5.00 per ton at the works.

The neighboring Illinois coals are well adapted for making a grade of coke, which, while inferior to the Connelsville coke, for smelting iron ores, would be excellent for smelting lead ores and for many industrial purposes as well as for special steam use as in locomotives.

With modern systems of coal washing on a large scale the coal

could be made very clean for a few cents per ton while special coking plants with provision for saving and marketing the tar and ammonia liquor should supply a satisfactory grade of coke superior to gas house coke and for a price which should not exceed $2.00 per ton.*

D. Gas considered as a fuel includes:

Natural Gas.

Retort or Coal Gas.

Water Gas—Uncarburetted and Carburetted.

Producer Gas.

Natural gas is that obtained from gas springs or by boring into the rock strata. The conditions for supplying useful quantities of this gas are not present in this locality so that it is not available in the solution of the smoke question for St. Louis, as it has been temporarily in Pittsburgh and other cities.

Retort or Coal Gas is that ordinarily produced in gas works for illuminating purposes. It has a very high heating power and is used to some extent in domestic establishments in this city for cooking and heating, also for a small number of gas engines.

The above remarks apply also to water gas which is manufactured to some extent in St. Louis but used only as a fuel gas. In its uncarburetted state it is much, and in its carburetted, quite, inferior to coal gas in heating hower.

Producer gas is of far less heating value than the other gases mentioned and is applicable to certain industrial operations where the conditions require and warrant the use of a special fuel clear of all impurities and readily controlled.

None of these gases can be used to advantage for firing boilers since their cost for evaporating a given weight of water is much greater than when using coal by direct firing. This is contrary to public belief but it is none the less a fact and easily susceptible of proof as will be seen later in this report. Coal gas and water gas or possibly some form of producer gas will doubtless be used in increasing quantities in domestic establishments as the public learn how to use it properly and the gas companies learn how to economize in methods of manufacture and distribution and to be satisfied with smaller profits. The convenience, cleanliness and efficiency of gas, when properly used, for domestic purposes constitute advantages which more than counterbalance the real or fancied increased expense over coal directly applied. The comparatively small consumption and intermittent character of

*Some years ago an experiment was made in a large scale to show the fuel value of washed slack. The quantity tried was upwards of 60 tons. It was from a pile of Belleville slack which had lain in the open air for years. After washing, by which the slates, iron pyrites, and fireclay were removed, its fuel value was somewhat higher than Big Muddy coal.

most of the fuel requirements in households are especially favorable to the application of gas.

E. Oil is used to a limited extent in a few works for the heating of iron and steel where a clean, easily controlled heat is required.

IV. The Various Classes of Fuel Users and their Relation to the Smoke Problem.

The smoke nuisance in any large city like St. Louis may be traced to four general classes of fuel users: domestic fires, industrial furnaces, locomotives and boiler plants.

Under the head of domestic fires may be included open grates, stoves, furnaces and ranges for heating or cooking, whether used in private houses, hotels or public institutions. In the abatement of the smoke nuisance this class is more difficult to deal with than any other for the reason that small quantities of fuel are burned at a time, in most cases slow combustion is required and excessive quantities of air are necessarily employed. The high temperature, therefore, so important for the combustion of the separated carbon which causes the smoke, is not readily attainable. It may be said also that this class of fires is very commonly in charge of people quite ignorant of the first principles of combustion and not particularly noted for their appreciation of the advantage derived from the application of intelligent effort. Any material improvement in the use of bituminous coal with a view to reducing the smoke due to domestic fires is not to be expected. The only complete solution of the problem so far as this class of smoke producers is concerned must be sought in the use of smokeless fuels such as anthracite coal, coke and gas.

The main objection, on the part of the public, to the more general adoption of these fuels in domestic establishments is doubtless the question of cost. It is probable, however, that an exaggerated view is taken of this objection and that the time is not far distant when the general use of bituminous coal, as at present, in our households will hardly be justified even on the score of economy. Anthracite coal has for some years sold in St. Louis for a price about three times that of the bituminous coal employed in domestic establishments but it is not improbable that the relation of prices will in the not distant future be somewhat more favorable to the anthracite, owing to reduced rates of freight, improved methods of handling and storage on the part of coal and railroad companies and of combining to purchase in wholesale quantities on the part of consumers. The concentrated character of anthracite, its high heating powers and the far higher efficiency with which it can be applied, as compared with bituminous coal, for such service as heating furnaces, base burner stoves and even cooking stoves and ranges where heavy duty and long hours are required,

enable the careful consumer to realize results, in the way of improved service, economy in consumption and saving in labor and repairs, which will be found to neutralize almost entirely even the present large difference in price per ton. Already the use of anthracite prevails to a large and increasing extent in the establishments of those having abundant means, while the great variety of base burner stoves of simple design and comparatively low cost of recent development has led to the extensive use of this excellent fuel in the homes of those even in very moderate circumstances.

For the ordinary operations of cooking, coke is admirably adapted, being almost without flame and furnishing a strong glowing heat. Its efficiency in cooking operations is notably higher than that of bituminous coal as commonly used. It is a common practice with cooks after charging the stove and range with bituminous coal to reduce the latter to a glowing bed of coke before making much if any use of the value of the fuel. With a large production of coke by gas and coke companies, more attention paid to quality and size, and with prices more nearly related to fuel value, the economical application of coke to ordinary cooking operations would compare very favorably with that of bituminous coal, and coke would doubtless soon become a favorite fuel in many households.

A notable beginning has already been made in the application of coal gas and water gas to household cooking and heating. As stated above, gas has special advantages for the comparatively short and intermittent service characteristic of many of the heat requirements of the household. These advantages are such that even at the comparatively high prices at present prevailing the economy may with good management be placed on the side of gas as against bituminous coal.

There were in use in this city for domestic service in the past two years, the following:

	1890.	1891.
No. of House Connections for gas stove use.	1560.	2385.

One great difficulty in the use of gas is the ignorance prevailing concerning its use. The common practice at present seems to be to purchase the gas stove at a hardware establishment and notify the gas company to make the necessary connection. No attempt is made, apparently, by the Gas Co. to instruct the customer how to use the gas to the best advantage* nor does the householder seem to take much interest in gaining the practical knowledge necessary to secure the most

*When Natural Gas first came into general use in boiler furnaces in Pittsburgh dense black smoke was often caused by its imperfect combustion, until the right methods and quantities of air admission, fire brick checker work, etc., were found by practice.

economical results. Too often it happens that to obtain more heat from a burner a larger quantity of gas is turned on when already the proportion of air admitted is insufficient.

With increased experience in the use of anthracite, coke and gas, and with a more general diffusion of right information concerning the comforts and economies of living, ever large proportions of bituminous coal will be replaced by these smokeless fuels in domestic consumption and thus a notable contribution will be made toward the clearing of our atmosphere. Fortunately, however, at present the domestic class of smoke producers is not the most objectionable. Though the chimney tops from which their contribution is made are the most abundant they are scattered over a great area and the quantity of smoke supplied by each is comparatively small and the more easily dissipated. This will be evident to any one comparing the atmosphere as regards smoke, on Sunday with that on week days.

Industrial furnaces may be considered as those used in the various processes employed in metallurgical and manufacturing establishments. The operations performed in these furnaces are frequently not alone dependent upon the generation of heat but upon special reactions which cannot easily be interfered with. Except in special cases they cannot be regarded as very objectionable smoke producers and the committee do not consider them of such importance in this connection as to call for immediate investigation and action.

Locomotives add very largely to the pollution of the atmosphere in this city because of their concentration in a few localities which are so disposed as to produce great volumes of smoke under certain meteorological conditions likely to intensify the effect. While in most of the important traffic centers the railroads arrive from many directions and operate in many parts of the city, in St. Louis there are only four localities where locomotives are very actively engaged: the old Mill Creek Valley, East St. Louis, the northeastern and southeastern parts of the City. In these places the switch engines, which are particularly offensive, are continually busy, while train engines at certain times of the day are also present in great numbers. When the wind is to any marked extent from the west but little if any annoyance is experienced from the smoke of locomotives, mainly because of their easterly location with reference to the city, but to some extent also on account of the dryness and buoyancy of our westerly winds. An easterly wind on the other hand drives the smoke from these locomotive districts over the greater part of the City and, being usually laden with considerable moisture, favors the development of visible smoke and vapor as well as a tendency to hang heavily in the lower atmosphere.

The remedy for this class of smoke producers must be sought in the use of a smokeless fuel like coke, especially for the switch engines.

The neighboring Illinois coals can easily be made to furnish a satisfactory coke for such purposes and at comparatively low cost, if such a market were established for the coke and the ovens were arranged for utilizing the by-products, tar and ammonia liquor.

The great offenders as smoke producers in this, as in every large city where the smoke nuisance prevails, are the boiler plants which continuously send forth volumes of black smoke from their tall chimney tops so that reasonable dilution is unattainable. The quantity of bituminous coal used, in the production of steam, forms a very important part of the total coal consumption in this City and any marked success in the abatement of the smoke from this class of fuel users must furnish the key to the practical solution of the smoke problem.

In dealing with this class of smoke producers it must be clearly understood at the outset that in St. Louis no assistance can be expected from the substitution of any of the smokeless fuels for bituminous coal. Anthracite coal, coke and gas are all out of reach in the matter of cost when compared with our bituminous coal for all such operations as steam raising where fuel economy is of paramount importance. Bituminous coal can be obtained for boiler purposes at a cost of $1.25 per ton while anthracite is not likely, within any reasonable time to reach so low a figure as $5.00 per ton. Keeping these figures in mind and comparing the heat values and efficiencies of these fuels we have the following convincing exhibit:

	Bit. Coal. (Common Illinois.)	Anthracite.
Heating Power. - - - -	9600 units.	13000 units.
Theoretical Evaporation (lbs. water per lb. of coal.) -	10 lbs.	13.5 lbs.
Efficiency, - - - - -	50%.	75%.
Evaporation in Practice, -	5 lbs.	10 lbs.

Two tons of Common Illinois bituminous coal at $1.25 per ton ($2.50) would therefore do the work of one ton of anthracite at $5.00. One hundred per cent. greater cost for fuel than is necessary to do the work is certainly a much larger contribution to the solution of the smoke problem than the boiler users of St. Louis are likely to make.

Coke as a fuel is far less adapted to stationary boiler work than anthracite and its price will never be such as to enable it to compete with bituminous coal for this class of duty even if it were in other respects suitable.

The convenience and economy attending the use of natural gas in a number of localities in this country have led many people to believe that fuel gas, made from coal at large central stations, and distributed to factories and works, is the fuel of the future which will not only clear all chimneys but reduce all fuel bills as well. While it is un-

questionably true that fuel gas is especially adapted for household use and will play an important part in the future for such use, it is equally true that as a fuel for raising steam it can never compete in the matter of economy with coal directly applied. At several establishments where gas is employed for certain industrial heat requirements attempts have been made to use the gas under boilers: at first glowing reports were circulated indicating a saving over coal of 20% and even $33\frac{1}{3}$%. A little experience has always shown, however, not only that such results are not attained but that the cost of the gaseous fuel is so much in excess of coal used directly as to make it necessary to return to the latter system.

The following simple calculation will serve to show the uselessness of all attempts to convert bituminous coal into gas and distribute it to boiler plants.

The average quality of fuel gas made from a trial run of several car-loads of Illinois coal in a well designed fuel gas plant showed a calorific value of 243391 heat units per 1000 cu. ft. of gas or 10105594 heat units per ton of coal. This is equivalent to 5052.8 heat units per pound of coal, whereas by direct calorimeter test an average sample of the coal gave 11172.6 heat units, or an efficiency of 45.2 %.

1 pound of the coal by direct application showed a theoretical evaporation of 11.56 lbs. water.

The gas from one lb. of the coal showed a theoretical evaporation of 5.23 pounds water.

48.17 pounds of the coal were required to furnish 1000 feet of the gas.

Taking the efficency in the use of the coal direct at 50 %.
Taking the efficency in the use of the gas direct at 90 %,
Taking the cost of the coal at 6 cents per bushel,
Taking the cost of the gas at 8 cents per 1000 cu. ft.,
We have as the cost of evaporating 1000 lbs. of water by coal directly applied:

$^{50}/_{100}$ of 11.56=5.78 lbs. water to be evaporated in practice by 1 lb. coal.

$^{1000}/_{5.78}$=173 lbs. coal to evaporate 1000 lbs. of water; 173 lbs. coal at 6 cts. per bushel=13 cents, and as the cost of the same coal converted into gas and applied:

$^{90}/_{100}$ of 5.23=471 lbs. of water to be evaporated in practice by gas from one pound of coal.

$^{1000}/_{4.71}$=212.3 lbs. coal required=4400 cu. ft. of gas; 4400 cu. ft. of gas at 8 cts. per 1000=35.2 cents.

It will be observed that the conditions assumed are especially fav-

orable to the gas, the cost being placed at the remarkably low figure of 8 cts. per 1000 cu. ft. which is about the actual cost of manufacture and distribution upon a large scale, and a very high efficiency is taken. Notwithstanding all this the coal used directly shows an advantage of over 170 %.

For fuel purposes two kinds of oil are used, crude petroleum, usually from Lima, O., and residuum after distilling off the lighter oils.

The Lima crude petroleum oil comes to this market in tank cars holding 6000 gallons. The price is 1.8 cents per gallon, to which must be added $5.00 per car for switching, etc. Even under favorable conditions, therefore, as to location of boiler plant, the cost of this oil delivered to the boiler will be at least 2 cents per gallon. A gallon of this oil weighs 6.9 lbs. The theoretical heat value of this oil is about 20.000 heat units, equivalent to a theoretical evaporation of 20.7 lbs. of water. Assuming an efficiency of 80 %, the evaporation in practice would be 16.56 lbs. of water per lb. of oil. The cost of evaporating 1000 lbs. of water would therefore be 17.54 cents. With a bituminous coal giving an evaporation in practice of 5 lbs. of water per lb. of coal and costing $1.25 per ton the same work could be done for 12.5 cts. a difference in favor of the coal of 40.32 %. It will be observed also that the conditions assumed in this calculation are especially favorable to the oil.

The "fuel oil" or "residuum" weighs about 7.3 lbs. per gallon and has a calorific power of 16880 or a theoretical evaporation of 17.47 lbs. of water per lb. of oil. At 3 cents a gallon and under the conditions assumed above the cost of evaporating 1000 lbs. of water would be 29.28 cents or 134 % more than when using the coal.

It is evident, therefore, that the only fuel likely to be used to any extent for boiler work in and about St. Louis is bituminous coal, and of a quality, as has already been explained, highly conducive to the production of abundant smoke when undergoing combustion. To secure a reasonable abatement of smoke under these conditions is the main problem requiring solution, and there are special difficulties attending it. In the vast majority of boiler plants of this city, the boilers are taxed, if not continuously at least an important part of the time, much beyond their capacity to furnish the steam demanded of them when consuming the limited amount of coal required for a good smoke record. In order to supply the additional power, therefore, excessive amounts of coal must be burned in a given time and under the ordinary conditions of combustion, dense clouds of black smoke are sure to result. In those cases where the boiler capacity is ample and the service comparatively light and uniform, as in running a few elevators, a small number of incandescent lights or serving a steam heating system, it is not a difficult matter, with ordinary care in firing, to

preserve a reasonable smoke record, The real problem is to burn large quantities of coal with comparatively smokeless combustion in a limited space with sudden and enormous changes in the demand which the fireman himself is unable to foresee and of which no notice can be given him. Careful tests in a manufacturing establishment have shown jumps of one hundred per cent. within an hour in the demand for steam varying from a little under the normal work of the boiler to eighty per cent. above it. Such sudden and excessive demands must be met by the stoker with his energies strained to a point where all other questions or considerations must give way before his supreme effort to hold the pointer on the steam gauge up to the necessary pressure as long as the demands continue. It is impracticable to time these suddenly increased demands so that the fireman may have fifteen minutes warning. Again, the character of the materials operated upon may change. Machinery will become deranged and worn, neglect at one point compels increased effort at another, a bad lot of coal comes in or the fires are dirty and clogged: the draft may be affected by a change in the direction and force of the wind, in the barometric pressure or in the temperature of the air. These things may happen singly or they may accumulate, but the work must go on and the fireman is obliged to throw in coal enough to keep everything moving: for in the boiler plant the latent energy of the coal is transformed into mechanical power, and this is the source of all various manifestations of force which are combined and utilized in the many processess of modern manufacture. These contingencies constantly arise in rolling mills, flour mills, tobacco works, breweries, distilleries, electric light stations, and electric power stations, etc. To burn coal to the best advantage under all these varying conditions, where the boiler plant and the hard worked stokers are called upon to equalize all these differences, and the hand on the steam gauge relentlessly registers the fact, is quite a different problem from burning a limited amount of coal steadily during a given time.

It may be urged that most of these conditions may be met by an increase in the boiler plant. This is true to a certain extent but it is often not possible to find room for more boilers. In many instances it would be necessary to take down needed machinery and remove it to other points. The relative position of one machine to another is often such that a change may disturb the whole process of manufacture. Additional boiler power generally calls for additional chimney capacity and there may not be room for that. It is in rare cases that the addition of even fifteen or twenty per cent. to the boiler power of an establishment can be accomplished with only a proportionate expenditure. There are many works in this city where not ten square feet of room can be found for an increase of boiler power.

V. The Conditions Under Which fuel is Consumed in Boiler Plants in St. Louis.

The difficulty of getting accurate and reliable information from the steam users of this city, concerning plant and practice, has been the cause of serious annoyance and hindrance to your Committee. There are few subjects apparently which are surrounded with so much unnecessary mystery or on which so little definite and accurate knowledge is obtainable. Many steam users go on from year to year without even an approximate idea of the amount of work their boiler plants are doing. Most of them know their annual consumption of fuel and can tell from their water tax receipts the total amount of water used in their works, but how much of this is converted into and used as steam is seldom estimated with any approximation to the real facts. Steam users are generally content with some arbitrary classification of their boilers such as 50 H. P., 100 H. P., etc. Such classification is usually based upon an empyrical assumption of a certain number of square feet of heating surface for a horse power. There is, however, a well established basis of computation, recognized among engineers, which fixes a horse power as the amount of steam obtained from the evaporation of 30 lbs. of water per hour. Many boilers classed as 100 H. P., run at only 75 to 90 H. P., and even less, while others of the same rating are pushed to 130 and 150 H. P. Thus we have a variation from 30 per cent. below to 50 per cent. above the normal capacity of the boilers.

In most cities of the Mississippi Valley, the boiler practice still bears the marks of having originated on the river. On steamboats the necessity of the situation required that a great deal of work should be done with comparatively light and therefore small boilers. In St. Louis our engine practice for many years followed that of the river in spite of entirely different conditions, and in the same way our land boiler practice has but gradually developed on its own legitimate lines. We find, therefore, that as a rule the standard horizontal tubular boilers are pushed to a much higher performance both in quantity and pressure of steam than is usual in land practice east of the Alleghenies, and this in spite of the fact that we have to do this pushing with a fuel far inferior to that used in the East. We have, therefore, doubly increased the difficulty so far as smokeless combustion is concerned. First, we have a coal which will make far more smoke than the anthracite, semi bituminous or even the bituminous coals, of the large manufacturing districts on the eastern slope, and, then while we have to use 25% to 50% more of it to get the same effect, we have been adding 40% or 50% to the work to be done by the same boiler, and hence in the same limit of space.

In attempting to get some reasonably approximate estimate of the

average conditions and work of the boilers in this city the Committee with the sanction and assistance of the Mayor, addressed to all steam users a circular (a copy of which is presented herewith, see Appendix I.) asking eight plain, practical questions. These circulars, to the number of over eleven hundred, were sent out by the City Boiler Inspector, with the request that they be returned with as clear and accurate answers to the questions as possible. Only seventy-eight, less then 7 per cent. were returned with any attempt to answer the questions and not one of these could be regarded as a satisfactory statement of the information asked for.

There were 78 reports made in all. As some especially requested their names to be withheld, we thought it but fair to mention no one. Out of these, seven were using Smoke Preventing Devices.

One of these gets less steam out of each pound of Big Muddy coal, than the average of good local practice shows for common Belleville Coal.

A second is perfectly satisfied, but he is using Big Muddy coal. A visit to his works by two members of the committee showed the remarkable fact that with the device in action the smoke disappeared in two minutes after firing, while when the device was shut off the smoke ceased in one and a half minutes.

A third reports heavy work, but as he has his own smoke preventing device, his testimony is naturally that of a party in interest.

A fourth reports favorably on the device used, but we found his work by data given us on the spot by the man in charge to be 35 per cent. below the ordinary rated capacity of such boilers, or say about 60 per cent. below the work frequently required of them in manufacturing plants.

A fifth reports favorably on device used, but the work of the boilers was found to be very light.

A sixth has since thrown out the device .as fuel wasting.

A seventh reports satisfactory results but the work is evidently very light.

Nineteen have used various kinds of smoke preventors but have thrown them out for various reasons. Of these one has spent about $8000; another $3000 on unsatisfactory experiments; a third found his "smoke consumer" consuming one-eighth more coal than the common furnace.

As coal consumption per square foot of grate per hour, the table shows a minimum of 7.5 lbs., a maximum of 31.2 lbs., and an average of 16.1 lbs. These figures alone suffice to show that in regard to smoke preventing devices "what is one man's meat" will prove "another man's poison."

In most of the plants reported on, the smoke continues more than

5 minutes immediately after firing. Since firing has to be done about every 15 or 20 minutes, it follows that when four or more boilers use one and the same chimney the smoke will be practically continuous. If the practice were to charge all furnaces simultaneously, the whole of this smoke would appear at once, while the total quantity would not vary at all.

As to the distance from grate to boiler, which has a direct influence on the production of smoke:

31 have 18″ and under, which may be considered as bad practice.

23 have between 18″ and 24″, which is fair practice.

21 have 24″ and over, which is good practice.

Twenty two plants have no margin of power at all; 12 have 25% margin or less; 27 have more than 25%.

It appears therefore from the table that less than 45 out of 100 of the steam plants in St. Louis could make use of the general run of "Smoke Consumers" without risk of shutting down. And out of these 45 probably one-half would find their limits drawn so close as to compel them to discontinue their use after a short trial.

VI. Requirements Necessary for a Successful Smoke Preventing Device.

To prove successful under the conditions, which, as outlined above commonly exist in the boiler practice of this city, a smoke preventing device must satisfy three sets of requirements:

I. *Efficiency.*—This includes (a) the development of such a high temperature and oxidizing action as to insure the combustion of the free or separated carbon which forms the visible smoke; (b) regularity of action under varying conditions such as are induced by charging fresh coal, cleaning fires, inattention of firemen, etc.; (c) not susceptable to derangement under conditions likely to obtain, as carelessness of firemen, inferior water, bad clinker, etc.; (d) small, if any increase in the cost of operating.

II. *Capacity.*—This must be such that efficient action will be secured not only when the boiler is working up to its full rated capacity, but even when forced in order to meet extraordinary demands.

III. *General Applicability.*—Under this head may be included (a) ready adjustment to all forms of boilers and boiler settings; (b) application where space is already limited; (c) comparative low first cost; (d) repairs, small in amount, easily made and low of cost; (e) operation without injury to boiler or other accessories.

It is hardly necessary to add anything explanatory of the above statement. In view of what has already been given showing the conditions relating to boiler practice in St. Louis and concerning the reactions involved in combustion and the prevention of smoke, these

requirements should be self-evident and considered all important.

Of the almost countless number of devices proposed there are few indeed incapable of showing good smoke results under special conditions. Those having decided merits (and there are many of these) are capable of successful operation when the conditions are generally favorable. The severe test and which very few are able to pass is that of capacity. With a fuel consumption up to 18 to 20 pounds of coal per square foot of grate per hour the better devices are able to show a good smoke record but to the extent to which combustion is pushed beyond these limits the chimneys return to their evil ways of polluting the air. The importance of this capacity test will be appreciated when it is understood that in the majority of boiler plants of this city the limits of fuel consumption, stated above, are greatly exceeded during an important part, if not the whole time, of their operation. It is not at all uncommon to find boilers in this city forced to the extent of burning 30 lbs. of coal per square foot of grate per hour.* Finally, it may be stated, without fear of successful contradiction, that not one of the devices so far brought forward is capable, in its present form and application, of fully meeting and satisfying all the requirements specified above.

VII. Classification of the Important Types of Smoke Preventing Devices Already Proposed, and the Principles Upon which they Depend.

It would be manifestly impossible to give in a report like this even a brief description of each of the many devices which have been introduced at various times for the purpose of preventing the escape of smoke. To mention each by name, and state its merits and defects, would be so incomplete a presentation of the case as might lead to misunderstanding and perhaps injustice. It seems wiser, therefore, to attempt only a general classification of the more important types and discuss the principles upon which their action depends, so that a clear understanding may be obtained of their limitations and of the outlook for the future.

*On March 10th, 1888, Mr. C. E. Jones of our Committee and Mr. Chas. F. White, recently appointed Smoke Inspector for the Citizens Committee in Chicago, made a report to Mr. N. O. Nelson, of the City Council, on Smoke preventing furnaces.

The heaviest loss by carbonic oxide gas escaping unconsumed was less than one per cent.

The results of 39 careful tests are tabulated. The smoke preventing furnaces on the average showed only 74 per cent. of the capacity of the common furnaces in burning coal, they reduced the work of the boilers 28 per cent., and they required about 2 per cent. more fuel to do the same work.

A. *Steam Jets.*—These consist of steam injectors to force air into the fire place either directly from the outside or after being heated. They have been applied in many ways and have been called by many names. The action is essentially the same in each whether the nozzles are placed in front above the fire doors, in the side walls of the fire place, or in the bridge wall. It is to supply air in sufficient quantity above the fuel bed for the combustion of all combustible material and to effect such a thorough mingling of the air, gases and carbon that combustion will take place more readily, and hence not far beyond the fire place. Where the heat is sufficient more or less water gas is formed by the decomposition of the steam into hydrogen and oxygen, the latter in a nascent state being more effective in oxidizing the separated carbon and the former readily burning back to water by combination with the oxygen of the air blown in.

These jets can be made to work satisfactorily where the demand upon the boiler is comparatively light and does not vary much but it is necessary to supplement their action with careful and regular firing. If too much coal is charged in the fire-place at a time the temperature is likely to be so much reduced that the action of the jets tends to retard rather than promote combustion. With variation in the demands upon the boiler the jets require corresponding adjustment to secure favorable resnlts. Such a system is, therefore, largely dependent for its successful operation upon the skill and faithfulness of the fireman. In most instances the capacity of the jet blowers is too small for the amount of work the boilers are called upon to do and where the capacity is sufficient it often happens that with the careless handling usually practiced the amount of steam used in the jets more than offsets any gain in efficiency due to improved combustion.* Another very important consideration is the setting and adjustment of the nozzles, which, if not very carefully attended to, may be the cause of a blow pipe action upon the boiler shell or grate bars resulting in a rapid burning of the metal especially from the strong oxidizing action of the decomposing steam. Several instances of this kind have occurred in this city.

It will be evident, therefore, that the steam jet blower system as usually applied and operated, is far from satisfying the requirements specified for a successful device. The determination of capacity and the adjustment in setting cannot safely be left to the boiler maker or boiler setter, nor to the engineer of the establishment, who is frequently only an engine tender. Nor can the operating of the device be left to the average fireman. On the other hand it may be said that

*At the Home Cotton Mills some years ago, steam jets over the fire were tried as smoke preventors. The result was an increase of 12 per cent. in the fuel consumption for the same work.

the requisite engineering skill and experience can always be obtained if sought for to secure a safe and suitable application of the system. The necessary qualities to make a reliable fireman can also be had if those interested would appreciate the importance and advantage of demanding these and of offering suitable compensation of faithful and efficient services. Under such conditions the steam jet system can undoubtedly be made to yield satisfactory results in controlling the smoke, especially where the boiler capacity is ample for the requirements and where the service is not too variable. These results can be attained, too, without injury to plant but not without some increase in the cost of operating. (See Appendix II.)

B. *Firebrick Arches or Checker Work.*—These have been applied in many ways and the resulting devices are known by many names. They are usually placed near the rear end of the fire place or over the bridge well. Their action is of a twofold character: first, to cause a more thorough mingling of the smoke and gases with air admitted above the fire bed, and second, to increase the heat of this mixture. The conditions favoring complete combustion, not only of the gases but of the more difficult combustible separated carbon at the same time, are thus brought about.

The arch causes the smoke, gases, and air to pass through a constricted passage close to the fuel bed which should be kept in the glowing coke stage. The arch itself serves not only to reflect the heat from the fuel bed but as a storage accumulator of heat which tends to regulate the heat and keep it up to a more uniformly high temperature.

The checker work is intended to produce the same result but in a slightly different way by dividing the general volume of smoke and gases into a number of small currents and causing more intimate contact with the firebrick surfaces.

So far as disposing of the smoke is concerned these appliances can be made to produce good results with careful firing. Their capacity in this respect is however, comparatively limited, being dependent upon the proportion of heating surface to the volume of gases and smoke to be heated and also upon the proper alternation of clear combustion, which supplies the heat to the storage surfaces, with the fresh coal firing which calls for the heat stored up. Another and more serious objection is their want of durability, and hence comparatively high cost due not only to the actual repairs, but to the interference with regular operations as well. Devices of this character cannot, therefore, be regarded as affording a satisfactory solution of the smoke problem. (See Appendix III.)

C. *Hollow Walls for Preheating Air.*—A number of patents have been taken out based upon this system but they are all likely to fail

short of satisfying the requirements specified. With careful firing in boilers performing moderate and uniform duty this system favors more complete combustion above the fuel bed by supplying heated air through a number of small holes or slits in the walls of the fire place and the bridge. It need scarcely be pointed out, however, that the capacity must be too limited to make its application to our boiler service of any material advantage. Other and well founded objections are that flues in the walls of a boiler setting are likely to make the construction less stable and durable. The openings, also, for the admission of air to the fireplace, readily become clogged and suffer from the ignorant and unfaithful labor frequently found in boiler service.

D. *Coking Arches or Chambers.*—This system is a favorite one with many inventors of smoke preventing devices. It consists in constructing a chamber in front of, or in an arch over, the forward part of the fireplace where the fresh coal is charged and retained until the greater part of the volatile matter is drawn off. The resulting coke is then pushed to the rear to serve as the hot bed over which the volatile matter from the fresh coal in front is made to pass. These devices are intended to accomplish more fully what is aimed at in the system of firing in an ordinary fireplace known as coke firing, which consists in firing in thin layers and small quantities at a time over the forward part of the grate and keeping the strong, clean heat of the glowing coke near the bridge wall.

For disposing of smoke these devices are effective only so far as the fireman is careful in working the fire and the amount of coal to be burned in a given time is limited. The use of arches, etc., in the fireplace is open to the objection that such constructions are necessarily short-lived, exposed as they are to high heats, changing temperature, and fluxing ashes.

E. *Double Combustion.*—Applications of this system have been attempted in many ways. Some have taken the form of duplicate fireplaces which are charged with fresh coal alternately. Suitable dampers or valves cause the smoke and gases from the freshly charged grate to pass beneath and thence through the other fire bed, which consists in the main of glowing coke. In other cases there is but a single fireplace, a portion of the smoke and gases being drawn by means of a fan blower from the breeching after having passed the boiler and forced under the grate to be passed through the fire bed a second time.

It is clear that in passing such a large proportion of useless gases through a fire bed much of the air needed for combustion will be crowded out and heat will be absorbed in raising the temperature of these useless gases to that of the furnace. The double furnace requires extra room and the single furnace a fan blower and both require

more skill and attention than can be expected of the average fireman. Those applications of this system that have been tried have generally proved short lived.

F. *Downward Draught-Furnaces.*—These have been applied in a variety of forms and under various patents for a number of years. They consist essentially of a fireplace with the back closed so that there is no direct communication for the smoke and gases to pass away under the boiler except downward through the fire bed. The closed back is formed either of a water leg from the boiler which passes below the level of the grate or a drum set below the level of the grate and connected at either end with the boiler by tubes, the space between the drum and the bottom of the boiler shell being bricked in, solid. Owing to the intense heat upon the grate, it is necessary to substitute a water tube grate for the ordinary bars and these water tubes are connected at the back with the water leg or drum, at the front, by means of headers and connecting tubes, with the boiler shell. All these parts, therefore, belong to the water circulating system of the boiler and supply so much additional heating surface.

The combustion of the fuel is effected, by such a device, in a far more rational way than on the ordinary fire bed. The fresh coal is as usual charged on the top of the bed but the air enters from the top and therefore cooler part, quickly gaining heat from contact with the heated coal and passes with the smoke and distilling volatile matter through the bed of incandescent coke below.

The separated carbon and all gaseous products thus become intensely heated. The moisture of the coal and the combined water of the volatile matter are decomposed into hydrogen and carbon monoxide gases which, with the aid of additional air supplied below the grate, burn with useful effect while the separated carbon disappears into invisible carbon dioxide gas.

In order to get the requisite amount of opening for draft the water tubes forming the grate must be spaced at greater distance apart than is the case with ordinary grate bars. Some of the fuel will, therefore, drop through, impelled by the force of the draft added to that of gravity. With caking coals such as most of our Illinois coal the loss from this source is not great under moderate firing. When, however, the fires are pushed and frequently worked with a bar to loosen the mass of coke or to clean the grate considerable coke falls through. This has led to the adoption of an auxiliary grate of ordinary type set some distance below and through this all the air is delivered for the combustion of the gases issuing below the upper grate. As the lower grate receives only the incandescent fuel falling from above the space between the two grates is in a favorable condition for completing the combustion, being highly heated and supplied with heated air.

Such a system is well adapted to insure a good smoke record even when the fire is forced and to a large extent with careless firing. It has the advantage also of being readily attached to a variety of boilers and such attachment serves to increase the heating surface and hence the capacity of the boiler.

The objections to this type of smoke preventing device, in any form in which it has been presented, arise mainly from defects in construction which although more or less serious can be overcome. The arrangement for admitting air for the lower grate through the floor plates in front of the boiler is defective, in that it does not permit of control of the air current. Excessive quantities of air enter, causing unnecessary waste of heat and a lowering of efficiency. The water tubes of the grate and the connecting pipes are liable to unusual strains at the joints and these latter are not altogether reliable. The water-leg or drum, which acts as an inverted bridge is subjected to intense heat as are also the tubes of the water-grate. Unless our St. Louis water is purified, scale will have a tendency to deposit at such places, especially on the lower surface of the water-leg or drum whenever there is any imperfect circulation. Any marked deposit of scale on these surfaces would cause the metal to burn rapidly and give way. While serious difficulties have not resulted to any great extent from these defects there is always more or less danger especially where higher pressures are carried, and these defects should be overcome before the system can receive unqualified approval.

In many boiler plants in this city, it would be difficult to apply this system owing to the lack of necessary space. A distance of two feet would be required between boilers or pairs of boilers to permit of cleaning the water-leg or drum. It is necessary also to have a greater depth of 18″ to 24″. Notwithstanding these various objections the system has so many valuable features that it gives great promise for the future and is well worth the attention and study required to secure the needed improvements, and adapt it to the exacting conditions of our local boiler practice.

G. *Automatic Stokers.*—There is a great variety of these devices, some of which are applied independently and others as auxiliaries to other types of smoke preventing devices. The principle involved in their operation is to secure regular and uniform feeding of coal to the fireplace by mechanical action in place of the irregular and unreliable service of the ordinary fireman. The mechanical action may be applied in the form of screw or hopper feeders to fixed inclined grates or to movable inclined or step grates. Most of these require the coal to be sized to nut, pea or slack grades and but few are capable of handling to advantage lump coal, or "the run of the mine." The coal when properly sized is fed with great regularity, thus doing away with the peri-

ods of heavy smoke development and clear firing. The gas and smoke are therefore distilled from the coal uniformly and near the upper or forward part of the grate changing the fuel to incandescent coke as it approaches the lower end of the grate.

While automatic stokers are capable of giving good results under favorable conditions their limitations are such that they cannot be regarded as applicable to any important extent for the boiler service of St. Louis. They require that a coal be used which does not readily cake and does not clinker to any serious extent. The boiler must be of ample capacity, also, so that no forcing is required. When, as is so generally the case here, a boiler is forced, the tendency of the coal to cake and clinker is very greatly increased. The moving grate bars often fail to prevent caking and the clinker is liable to choke the bars and impede their action. To clean a fire by hand where an inclined or a step grate is used is a very laborious and tedious undertaking for the fireman and he is too apt to shirk it or perform it inefficiently. Another limitation lies in the fact that although automatic stokers are provided with devices for varying their speed, they cannot act as promptly nor follow the variations in demand as closely as the fireman with shovel and slice bar. With our caking and hard clinkering coals and overworked boiler plants, any system with such limitations is likely to prove worse than useless, as a device to diminish smoke or economize fuel.

The fact must not be lost sight of that in using any form of smoke preventing device, greater care must be exercised in the examination of the boiler and that more frequent cleaning of the interior is required. The better the combustion and the higher and more concentrated the heat resulting from this, the greater the danger of over-heating and burning the portions of the boiler heating surface on which mud or scale may lodge. It is well known that mud and scale will more readily settle on those portions of the furnace sheets receiving the most direct action of the flame, since rising currents will always be established there inducing return currents from other portions of the boiler which sweep scale and mud and all suspended impurities to these points. In those devices, in which danger points are covered or obscured from the eye of the fireman or engineer, the danger is of course increased. Boilers of inferior design, imperfect in construction, or defective to any extent in circulating action, will be rendered less secure by the application of any such devices as promote more efficient combustion. Your Committee therefore inclines to the belief that, before a general adoption of these devices, the use of a simple but effective system of purifying the feed water before it enters the boiler will be necessary.

VIII. EXPERIENCES IN OTHER CITIES RELATING TO THE ABATEMENT OF THE SMOKE NUISANCE.

PITTSBURGH, although possessing steam coals capable of nearly 50% greater economy in boiler furnaces than our standard fuels, was long known as the Smoky City. She succeeded in temporarily clearing her atmosphere by the use of Natural Gas, but is now rapidly relapsing into her former state.

The City Councils of Allegheny City (practically a part of Pittsburgh) have been already wrestling with the question of preventing the increase of the Smoke Nuisance, as evidenced by a letter to Mayor Noonan, asking several of the very questions which were placed before us for solution. The letter shows that they have no more knowledge of the problem than is usual among our citizens.

CINCINNATI with the same superior Pennsylvania coal brought to her doors by cheap river freights has long had a Smoke ordinance which as a solution of the problem is a complete failure. It provides (See Appendix IV) that anyone using a steam boiler without an efficient smoke preventing device shall be fined not less than $50 nor more than $100 for each offence, and similar penalties are held over the men in charge of such boilers.

The Supervising Engineer who has charge of the enforcement of this ordinance wrote us that there was but *one device* in use which comes near being a smokeless furnace, and that "*must have perfect conditions.*" Many steam jet devices are in use "but they soon burn out and are not economical in the use of fuel."

Devices with brick arches over the furnace have answered fairly well if the boiler is ample for the work, "*and they have a good draft,*" but expansion and contraction soon wrecks them and parties will not maintain them.

When short of boiler capacity even the device above mentioned as the best "will smoke like a tar kettle." "A majority of boiler settings *are too shallow between grates and boiler*, so there is no room for the proper mixture of the gases, which together with a *sluggish draft, due to low stacks* in many cases, and the putting of two or three boilers into a chimney originally intended for one, makes a condition of things hard to deal with, when the suppression of smoke is considered."

"The intermittent work of a boiler adds to the difficulty, etc." When it is remembered that Cincinnati need burn but 67 pounds of a much less smoke producing coal to our 100 pounds of a very smoky fuel, the failure of merely restrictive legislation is apparent.

CHICAGO has long had a smoke ordinance and, if there were a sovereign virtue in such legislation, the Smoke problem should have been solved there long ago.

For, while the common Illinois coals cost much more than in St.

Louis such better and less smoky fuels as the Indiana block, Youghiogheny, and even Anthracite coals are brought to her at much lower figures than to us: in fact at prices which make them available as steam coals.

Prices range about as follows:

	PER TON.
Illinois coal,	$2.25.
Kentucky lump coal,	3.35.
Indiana block coal,	2.75.
Indiana Hazel coal,	2.25.
Cumberland coal,	4.00.
Youghiogheny coal,	3.75.
Hard coal Screenings,	1.50.
Hard coal (Anthracite),	5.75.

Mixtures, of much higher fuel value and much less smoky, have been, and are being tried to meet the stringent conditions of the smoke ordinance. F. I. mixtures of 15 to 33% hard coal screenings with Kentucky lump or Indiana block are being used with very fair success.

In one plant a mixture of

80% Indiana block at $2.75 per ton,	$2.20
with 20% Anthracite screenings at $1.50 per ton,	0.30
gave a practically, smokeless mixture at	$2.50

per ton, being only 25% per ton more than common Illinois coal, but possessing in practice a fuel value possibly 40% greater.

With this mixture as high as 24¼ lbs, of coal per square foot of grate have been burned per hour running the boilers 33% above rating, without coming under the censure of the Smoke Inspector, and that with a common furnace without any smoke preventing device.

In spite of these facts, in spite of the simple and stringent Smoke ordinance (see Appendix V) which has been in force for some years, stimulating the efforts of inventors and promoters of so-called Smoke Consumers, Chicago remains nearly as smoky as before.

Finally, in the last week of 1891 a large meeting of prominent citizens, representing fifteen city clubs, and commercial bodies, was held and a Committee of Seven appointed to take the matter up in earnest. They have practically reached similar conclusions to those we have the honor to submit to you herewith, namely that an educational campaign must precede any restrictive legislation.

A Society for the Prevention of Smoke has been formed, numbering among its members some of the most prominent men in all the business Community, and large sums of money subscribed to carry on the work.

Two experts have been appointed, at good salaries, who, with a

corps of assistants, make tests of boilers and of smoke preventing devices, with a view to determining the exact conditions of each smoke problem and the limitations of devices offered. This follows out pretty closely the line of work your Committee had laid down as necessary, in their preliminary report of November last, which they now have the honor to give in full detail as their "Conclusions and Recommendations."

It is interesting to note that out of thirty-seven plants reported by the City Smoke Inspector for maintaining a Smoke Nuisance on Jan., 1st, 1892, six had in use well known and more or less meritorious "Smoke Consumers." Nothing could better illustrate the necessity of careful tests to show promoter and purchaser alike the exact limitations of such devices, and their applicability to a given set of conditions.

IX. Conclusions and Recommendations.

While, as will have appeared from the foregoing, this Committee is unable to say that the practical problem of smoke prevention, under St. Louis conditions, is fully solved, we can say that substantial progress in that direction has been made.

A number of meritorious devices are in the market. We can not recognize any of them as of unlimited or unconditioned effectiveness. What their practical limitations are, we are compelled to think that neither those who have invented, sold or used them, know.

The smoke nuisance affects the whole community, and all are interested in getting rid of it. All will admit that there is a great but uncalculated money loss, in destruction of goods and furnishings, in defacement of buildings, in labor and material expended in the vain effort to keep clean, and in increased necessity for artificial light: an æsthetic loss through discouragement of the ornamentation of buildings, homes and grounds; a sanitary loss in impared health and prevalence of lung and throat troubles; a population loss, in those who cannot or will not live in a begrimed city, and last, not least, a moral loss, in the effect on those who per force endure dirt and unwholesomeness. Great as the evil has been and is, its increase, if unchecked will be in a more rapid ratio than that of population.

The time has come when a decided step should be taken. In that step, it is appropriate that the city through its government should take the lead, for the city authorities are themselves among the offenders. We would not advise any arbitrary action, but some pressure should be brought to bear upon those who produce the great part of our smoke cloud: for, while some are alert and willing to spend money to abate their share of the evil, the majority may safely be supposed to be inert and as unready to make an effort to abate as they

have proved unwilling or careless about responding to inquiries for facts. We do not think that the cloud can be entirely removed in the immediate future but we are sure that its density can be very materially reduced, not without cost, but without hardship to any. Yet all should be willing to exercise patience and even make some concessions.

As an indispensable preliminary to repression, we think that authoritative and impartial determination should be made:

1st. Of the practical bounds within which smoke emission may be confined now, taking emergencies and all valid excuses into account and defining them for the information of fuel consumers, and for the guidance of the authorities in dealing with them.

2nd. A determination of the quantitative and economical limitations of various devices and their adaptability to special requirements.

To do this work a paid expert commission will be necessary; and the expense of such a commission should be borne by the public. That of preparing for test should be borne by the promoters of each device and the cost of testing, in part, by promoters and, in part, by the public.

Finally, we call attention to a matter, seldom thought of in this connection, relating to the plan and construction of buildings.

The modern business building nearly always contains a steam plant for heating and other incidental uses. This plant is not regarded as revenue producing direct, and architects as well as owers are disposed to place it so as to occupy the least possible space. Hence it is in most cases inconveniently located, cramped for room and but little regard paid to ventilating. Flues and chimneys are often unskillfully proportioned, and the comfort of attendants so little considered that they can do no better than stuff the furnace and go out to breathe.

Recommendations.

In view of the facts and considerations, presented above, your Committee would respectfully make the following recommendations and urge immediate action upon them:—

I. The introduction in the Municipal Assembly of two ordinances, (drafts of which are herewith presented).

A. An Ordinance Declaring the Emission of Dense Visible Smoke to be a Nuisance and providing for the Suppression thereof *within one hundred and eighty days after the enactment of this ordinance.*

B. An Ordinance Authorizing and providing for the Making or Regulations Limiting and Defining Permissible Smoke Emission; for the Testing of Smoke Preventing Devices, and for the Making of such Tests and Experiments as may be Deemed Advisable with a view to the Abatement or Suppression of the Smoke Nuisance.

II. The introduction in the Municipal Assembly of an amendment to the present Boiler Inspection Ordinance with a view to regulating the size, proportions and fittings of boilers to be erected hereafter and the accommodations to be provided for such boilers.

III. That steps be taken at once to diffuse as thoroughly as possible among the public, especially housekeepers, manufacturers and railroad officials such facts and figures and right information concerning these as may aid them in the early general adoption of smokeless fuels so far as they may be applicable, as:

A. In domestic establishments, anthracite, coke or fuel gas.

B. In industrial furnaces, other than boiler plants, coke, fuel gas or oil.

C. For all switch engines and such as operate within the City limits, coke.

The following are drafts of the ordinances suggested:—

An Ordinance, Declaring the Emission of Dense Visible Smoke to be a Nuisance, and to Provide for the Suppression Thereof.

Be it ordained by the Municipal Assembly of the City of St. Louis as follows:

Section 1.—The emission into the open air of dense visible smoke within the corporate limits of the City of St. Louis is hereby declared to be a nuisance. The owners, occupants, managers or agents of any establishment, locomotives or premises from which dense visible smoke is habitually emitted or discharged shall be deemed guilty of a misdemeanor, and, upon conviction thereof shall pay a fine of not less than ten nor more than one hundred dollars. And each and every day wherein such smoke shall be emitted shall constitute a separate offense.

Section 2.—The President of the Board of Public Improvements is hereby authorized and directed to appoint with the approval of the Mayor, such inspectors, not exceeding five in number, as may be necessary to carry out the provisions of this ordinance. Said inspectors shall receive a salary of one hundred dollars a month each, payable monthly.

Section 3.—The inspectors shall have a right to enter, in the performance of their duties, at reasonable hours upon all premises other than dwelling houses occupied by less than four families or tenants. They shall collect evidence of the facts in cases of the violation of this ordinance, and, with the approval of the President of the Board of Public Improvements in each case shall report the same to the City Attorney for prosecution. The inspectors shall be guided in the performance of their duties, by instructions given by the Board of Public Improvements, and approved by the Mayor, from time to time.

SECTION 4.—This ordinance shall take effect at the expiration of six months after its approval by the Mayor.

AN ORDINANCE, Authorizing and Providing for the Making of Regulations Limiting and Defining Permissible Smoke Emissions, and for the Testing of Smoke Prevention Devices, and for the making of Such Tests and Experiments as may be Deemed Advisable With a View to the Abatement or Suppression of the Smoke Nuisance.

Be it ordained by the Municipal Assembly of the city of St. Louis as follows:

SECTION 1.—The President of the Board of Public Improvements is hereby authorized and directed to appoint with the approval of the Mayor, a commission composed of three competent persons, who shall not be directly or indirectly interested in the manufacture, sale or construction of any furnace or other article having practical relation to the production or prevention of smoke.

Said commission shall ascertain, and report to the Board of Public Improvements, the conditions and liabilities under which manufacturing and other parties cannot wholly or reasonably prevent the occasional production and emission of dense visible smoke. Such ascertained conditions and liabilities, when approved by the Board of Public Improvements and Mayor shall be published and thereafter shall constitute instructions to guide and limit the officials charged with the enforcement of smoke suppression ordinances. And it shall be a valid and sufficient defense against any complaint, that the offence charged comes within such recognized conditions and liabilities.

Said commision shall conduct and make practical tests of all devices for the prevention or suppression of smoke which shall be submitted to them, in accordance with the conditions hereinafter set forth, and shall prepare detailed reports, stating the facts and conclusions based thereon as to the efficiency of each such device, the conditions of its successful operation and the limitations to its efficiency. Said report shall be made promptly when any test is completed, to the Board of Public Improvements, which report may be rejected by said Board if found to be unfair or untrue. If accepted by said Board the report shall be published for the information of the Public. Provided however, that such acceptance and publication shall not be constructed as an endorsement of the report by the City of St. Louis or as a recommendation for or against, the device passed upon.

Said Commissioners shall also be called upon, by the President of the Board of Public Improvements, to make such tests and experiments as may in his judgment be needed to determine the applicability of special or smokeless fuels to domestic, locomotive or other uses, with a view to the abatement or suppression of smoke, and shall prepare

detailed reports of the results together with such conclusions and recommendations as in their judgment may be warranted by the facts, said reports to be made promptly and printed for the information of the public.

SECTION 2.—The Commissioners authorized by the preceding section shall receive in compensation for their services in ascertaining and reporting the conditions and liabilities of Smoke Suppression the sum of one thousand dollars each, payable upon the certificate of the President of the Board of Public Improvements that such report has been made to, and accepted, by the Board of Public Improvements. For their services in conducting tests of devices and making report thereon they shall each receive the sum of Seventy-five Dollars for each device tested and reported, and for conducting the special tests and experiments, as provided in the preceding section, one hundred dollars for each series of tests or experiments together with a full report of the same. Said respective sums to be paid on the certificate of the President of the Board of Public Improvements that the report of such test has been received and accepted by said Board.

Incidental and necessary expenses, for the above described investigations and tests, shall be allowed and paid for as other expenses of the office of the President of the Board of Public Improvements.

SECTION 3.—Any party having or claiming to have a plan or device whereby smoke can be prevented or suppressed, and desiring to have the same subjected to a practical test and determination, may do so on the following conditions:

First.—He or they shall notify in writing the President of the Board of Public Improvements that such a test is desired, and with such notice shall file a full and complete description of the device with all necessary drawings to show its character, construction and mode of operation. Accompanying such notice shall be a certificate of the City Treasurer that there has been deposited with him to the account of contract and other deposits the sum of one hundred dollars.

Second.—If the President shall judge that the public interest and the probable merits of the device justify a test, at the City's expense he shall instruct the Commission to make it whereupon the sum deposited shall become the property of the City of St. Louis and shall be credited to the fund for testing smoke prevention devices. If the said President shall judge that the public interests or the probable merits of the device do not justify a test, at the City's expense, he may refuse it, whereupon the sum deposited shall be returned to the depositor. But the party interested may pay into the City treasury the sum of four hundred dollars to the credit of the fund for testing smoke prevention devices, and, upon the presentation of the Treasurer's certif-

icate to that effect, the President of the Board of Public Improvements shall order the Commission to make the test.

Third.—The party or parties submitting a device shall erect the same at the place designated by the Commission, or at such other place as the Commission may approve of, at their own cost and expense under their own supervision, with such provisions for the attachment of instruments as the Commission may require, and, when fully ready, shall deliver the premises and equipment to the Commission.

If the place is furnished by the Commission such erection and delivery shall be made within thirty days after the place is put at the disposal of such persons, and after the test is closed said device and all its belongings shall be removed within 15 days after notice to that effect.

Fourth.—If after test is begun, alterations or improvements are desired to be made the party interested must proceed as if submitting a new plan or device. Unless the several Commissioners shall each consent to such alterations and waive all claim for compensation for a partial test.

SECTION 4.—Whenever the Mayor shall be of the opinion that the public interest does not warrant the further testing and reporting on devices, under the authority of the City of St. Louis, he shall notify the President of the Board of Public Improvements to that effect, in which event the existence of the Commission, hereby authorized, shall terminate when tests already in hand shall have been completed and reported as herein provided.

Your Committee believes that these two proposed ordinances embody the best form of municipal action in the premises. While, possibly, further discussion on the part of all interested in the subject may suggest certain modifications, the main point must be kept in view. It is, that the City government owes it to the manufacturing interests to present—first the ways and means in which smoke may be prevented under existing economic conditions, before it has the right to pass or enforce smoke ordinances similar to those of Cincinnati and Chicago.

We sincerely believe that when the means are once shown clearly, the public spirit of the large majority of our manufacturers will induce them to adopt such means without waiting for any mandatory law.

Very respectfully submitted,

E. D. MEIER, Chairman.
WILLIAM B. PORTER,
ROBERT E. MCMATH,
C. E. JONES, Committee.

APPENDIX I.

To Steam Users of St. Louis:

Gentlemen.—The undersigned Committee, appointed by the Mayor of the city, at a recent meeting of manufacturers and others, called to consider the smoke nuisance, request your co-operation by answering the following questions, or as many of them as you can answer correctly with reference to your own boiler plant and daily experience. The Committee will consider your communication confidential, if you so desire it, using the facts and quantities only, without referring to the plant to which they refer, in making up a tabular statement, showing the exact extent of the difficulties which the solution of this problem presents.

1. Please state the number and size of your boilers, *i. e.*, diameter and length, and the number, diameter and length of flues or tubes in each; please give also the clear length and clear width of grate under each boiler or battery, as well as the clear height from top of grate to bottom of boiler.

2. Please state diameter or square, and height of your chimney, counting the height from the level of the grade.

3. What kind of coal (name mine if possible), do you use, and is it "Run of the Mine," "Slack," "Nut" or "Lump?" and how many pounds or bushels do you burn per hour?

4. Is your boiler plant taxed to its full capacity, or have you any margin over your actual necessities, and if so, how much?

5. Does the work required of your boilers vary during the day, and within what limits, and what is the nature of the variation, *i. e.*, frequent and sudden, or regular and at long intervals?

6. How many pounds of water do you evaporate per pound of such coal as you use, taking actual weights and measurements? State also in this connection the temperature of your feed water as it enters the boiler, and the steam pressure you generally carry as shown by gauge. In answering this question it is not necessary to make an expert test, but you can no doubt give the amount of coal for a number of months back, from your coal bills, and your meter readings for the same time, and enable the Committee to make this computation. If you have ever used any smoke consumer, or smoke preventing furnaces or devices, or are now using same, please state the results as compared with those obtained with plain furnaces and plain grates.

7. How many pounds of coal per square foot of grate do you burn per hour without making smoke?

8. How many pounds of coal per square foot of grate do you burn

per hour with no smoke except for one or two minutes after each firing, or how long after each firing does smoke continue?

Please send replies to this Circular to the "Smoke Prevention Committee," care Commissioner of Buildings, City Hall.

APPENDIX II.

The loss or consumption of Steam by steam jet blowers is found to be very large. Experiments made at the New York Navy Yard with five different types of nozzles are reported in *Engineering News* of September 19th., 1891.

The nozzle consuming the largest amount of steam was an annular slot. As its exact dimensions are not given we cannot well compare it with the others.

The other four compared as follows:

	Single Round Hole of			33 Holes, each of
	1/16 diam.	1/8 diam.	9/64 diam.	1/32 diam.
Per cent. of total steam.	8.3%	12%	14%	20.7%
Pounds steam per hour.	7.5	15.8	19.06	30
Loss in H. P..	0.25	0.53	0.653	1.0

As the supply pipe to the nozzles was very small it is highly probable that the loss by the larger nozzles would have been proportionately greater had the supply been ample,

APPENDIX III.

As further illustrating the losses due to smokeless combustion we append the average results of some interesting practical tests made in Chicago, by Mr. Wm. C. D. Gillespie, M. E., Chief Engineer of the Rookery Building. The aim was to produce smokeless combustion at any cost. The coal used was much less smoky than our St. Louis fuels viz., Indiana Block coal whose price precludes its use under boilers in this city.

The tests were divided into three series, each recording the average results reached by improvements in the furnace. They show both a decrease in power and a loss in economy the more they approach perfectly smokeless combustion.

The boiler was of the horizontal tubular type 60″ diameter by 14 ft. long, with 46 tubes 4″x14 ft. It had 620 sq. ft. of heating surface and 16 ft. of grate area, a very favorable proportion for economy. The furnace was of the fire brick arch type, the arch being very long, 9 ft. in all, of which all but 1½ ft., were in front of the boiler. There is provision for air admission over the fire. The grate as well as the arch incline downwards from the fire front to the boiler.

The record, condensed to its essentials is as follows:

TESTS.................	FIRST SERIES.	SECOND SERIES.	THIRD SERIES.
TIME..................	4 days of 9 hrs. each.	5 days of 9 hrs. each.	5 days of 9 hrs. each.
Pounds Coal burned per sq. ft. grate per hour.	24.34	24.59	23.82
Horse power developed.	102	93	89
Boiler ran above rating.	25%	13%	10%
Conditions as to smoke.	Moderate Smoke	Smoke Much Reduced	Practically Smokeless
Loss in power by reducing smoke..................	0	12%	15%
Loss in economy by reducing smoke....................	0	$7\frac{1}{2}$%	$13\frac{1}{3}$%

Mr. Gillespie writes us later (March 9th,' 92) that he has made further improvements by which he gains considerably in economy.

APPENDIX IV.

CINCINNATI SMOKE ORDINANCE.

An Act to Provide for the Better Protection of Human Life Against Fire, and regulate the Construction and Management of Steam-Boiler Furnaces in Cities of the First and Second Grades of the First Class.

SECTION 4.—Every steam-boiler furnace used within the corporate limits of any city of the first grade of the first class shall be so constructed or altered, or have attached thereto such sufficient smoke preventives as to produce the most perfect combustion of fuel or other material from which smoke results, and so as to prevent the production and emission of smoke therefrom so far as the same is possible. And any person or persons, association or corporation, being the owner or lessee, or having control of any such steam-boiler furnace (who) shall use or allow the use of any such steam-boiler furnace which shall not be so constructed, or if already constructed at the time of the passage of this act shall not be so altered, or shall not have attached thereto such efficient smoke preventives as to produce the most perfect combustion of fuel or other material from which smoke results, and so as to prevent the production and emission of all smoke therefrom so far as the same is possible, or shall fail to keep such steam-boiler furnace for the prevention of smoke, and such smoke preventives in good and efficient order and operation, shall be subject to a fine of not less than twenty dollars nor more than fifty dollars for the first offense, and for each subsequent offense shall be fined not less than fifty nor more than one hundred dollars. And no steam-boiler furnace shall hereafter be constructed in any city of the first class, except in

accordance with the requirements of this section, under the penalty of fifty dollars for each offense.

SECTION 5.—Every person having charge of the igniting, making, stoking, feeding, or attending any such furnace and any smoke preventives attached thereto in good and efficient order and use, that the least possible smoke shall be produced and emitted therefrom, and any such person who shall fail or neglect to so ignite, make, stoke, feed, or attend such furnace fire that the least possible smoke shall be produced or emitted therefrom, or shall fail or neglect to keep such furnace or smoke preventives attached thereto in good and efficient order and use, or shall hinder or disarrange any such furnace or smoke preventives attached thereto, shall be subject to the payment of a penalty of not less than twenty dollars nor more than fifty dollars for the first offense, and not less than fifty dollars nor more than one hundred dollars for each subsequent offense.

SECTION 6.—The mayor of the city in every city of the first grade of the first class shall appoint a person of suitable qualificatious as supervising engineer, who shall hold his office for the term of two years, from and after the date of his appointment, and until his successor is appointed and qualified; and he shall have authority to supervise and require all steam-boiler furnaces in such city of the first grade, of the first class to be constructed, or if already constructed to be so altered or have attached thereto such efficient smoke preventives, so as to produce the most perfect combustion of the fuel or other material from which smoke results, and so as to prevent the production and emission of all smoke therefrom so far as the same is possible, and he shall further have authority to supervise the iguiting, making, stoking, feeding, and attending such steam boiler furnace fires; and he shall have further authority, in the performance of the duties of his office, to enter any steam-boiler or engine-room, or any building not occupied exclusively as a private residence, and any person or persons hindering or obstructing him in the performance of such duties shall be subject to a fine of not less than twenty dollars nor more than fifty dollars, or imprisoned in the workhouse for a period not exceeding thirty days.

SECTION 9.—The penalty for any violation of the provisions of this act, not otherwise especially provided for, shall be not less than twenty dollars, nor more than fifty dollars, for the first offense, and not less than fifty, nor more than one hundred dollars, for each subsequent offense.

SECTION 10.—All acts or parts of acts inconsistent or in conflict with this act, be and the same are hereby repealed.

SECTION 11.—This act shall go into effect and be in force from and after its passage.

APPENDIX V.

CHICAGO SMOKE ORDINANCE.

SECTION 1650.—The emission of dense smoke from the smoke-stack of any boat or locomotive, or from any chimney anywhere within the City, shall be deemed, and is hereby declared to be a public nuisance: *provided*, that chimneys of buildings used exclusively for residences shall not be deemed within the provision of this ordinance.

SECTION 1651.—The owner or owners of any boat, or locomotive engine, and the person or persons employed as engineer or otherwise, in the working of the engine or engines in said boat or in operating such locomotive, and the proprietor, lessee, or occupant of any building, who shall permit or allow dense smoke to issue or be emitted from the smokestack of any such boat or locomotive, or the chimney of any building within the corporate limits, shall be deemed and held guilty of creating a nuisance, and shall for every such offense be fined in a sum not less than five dollars, nor more than fifty dollars.

SECTION 1652.—It shall be the duty of the Commissioner of Health and the Superintendent of Police, to cause Sections 1650 and 1651 of this article to be enforced, and to make complaint against and cause to be prosecuted all persons violating the same.

THE DEVELOPMENT OF TRANSPORTATION SYSTEMS IN THE U. S.: FINANCIAL POLICIES, AND THE RESULTS TO WHICH THEY ARE LEADING.

BY HORACE A. KEEFER, MEMBER ENGINEERS' CLUB OF KANSAS CITY.

[Read April 11, 1892.]

There is perhaps no time in the history of man-kind upon which there is more universal interest exhibited or more thought directed by a nation than that of the final trend of the great corporations controlling the carrying power of our American Highways. To clearly show the growth and importance of this greatest of all our industries, it will be necessary, to give a brief outline of the earliest modes of Transportation. Passing over the period of the first European settlers who followed the Indian system of conveyance by means of boats on natural water courses, and the pack train of which in 1784, contracts were made for merchandise to be transported from Philadelphia to Erie for $249 a ton, we arrive in Sept., 1807, to witness Robert Fulton's first successful trip with "The Clermont," on which steam-boat he made the trip between New York and Albany, a distance of 150 miles in 32 hours.

or nearly 5 miles per hour. About this time turnpikes were established between some of the important towns in Pennsylvania, New York, and the seaboard cities, and the rate of carriage was about 13-5 cents per ton per mile, and later on merchandise was carried in Conestoga wagons for 37 to 50 cents per 100 lbs. between Philadelphia, and Columbia, 74 miles; and Philadelphia, to Pittsburgh for $2.50 per 100.

The distance between Baltimore and Wheeling, 266 miles was performed in this manner in 15 days and the rate on merchandise about 17 cents per ton per mile or $44.80 per ton. As late as 1821, the rate between Philadelphia and Pittsburgh was as high as $11.00 per 100 or about 70 cents per ton per mile. Prior to 1824 the rate between New York and Buffalo over natural highways was $100.00 per ton, the cost of transporting cereals say 50 lbs., 50 miles, was 20 cents or about 15 cents per ton per mile. The cost of Transportation in the south over poorer roads and when oxen were used was double or about $20.00 per ton for 50 miles. In the west as late as 1868, the Government paid for transporting Quartermasters' stores from the end of the K. P. Ry., to troops in New Mexico at the rate of 25 6-10 cents per ton per mile. In 1816 the steamboat charges between Louisville & New Orleans were 5 cents per lb. Prior to the establishment of railroads west of the Mo. R., transportation between it and Denver was about 1 cent per pound. In 1825, the Erie Canal was completed which inspired by its success other states to construct competing or connecting lines. This work was prosecuted with vigor until 1840. In 1829, Mr. Josiah White, Mgr. of the Lehigh Coal & Nav. Co., gave the cost of transporting coal as follows:

In boats of 40 tons burthen, 1 ct. per ton per mile.
" " " 67 " " 7-10 " " " "
" " " 134 " " 1-2 " " " " and by transportation by Tram Railway 3 55-100 cents per ton per mile. The tolls charged by the New York Canals from 1856 to 1872 was from 672 mills per ton mile, the lowest in 1859, to 11-10 mills the highest in 1856.

Passenger travel between 1834 and 1854 by packets was considered luxurious and a distance of 3 to 4 miles per hour was effected.

The first American Ry., was probably a short line built by Silas Whitney in 1807 on Beacon Hill, Boston. In 1820 this had been followed by five other short lines, mostly of wooden trams. Our first era of Railroads really dates from 1830, at which time there was less than 40 miles in the United States, but sufficient changes had been going on in the last 5 years to change the prevailing sentiment against them.

In 1829 the first Locomotive was given a successful trial at Honesdale, Penna.; such were the prejudices and fears at that time, it was hardly possible to obtain a man to fire and run it, and no one could be induced to get upon it, but the man who dared connect his name with running the first Locomotive in America, Horatio Allen.

In the period between 1830 and 1840, there was constructed in the United States 2,264.67 miles of road.

By the New England States,......................356.68 miles.

" Maryland, Del., N. J., & D. of C................

" N. Y., Penna., O., Mich. & Ind ....1399.89 "

" Southern States,..............................508.10 "

The cost of constructing 1 mile of Granite Ry., on the Columbia & Phila. Ry., in 1832 was $10,179 per mile; on the Mine Hill & Schuylkill Haven Ry., in 1831, $12,000. It was demonstrated before the opening of this decade that where Railways came into competition with canals, the charges must be 1 cent. per ton a mile or under, and this prevented exorbitant rates to start with.

The early reduction in charges, even where there was abundance of tonnage, was greatly retarded on the early railroads by the lack of equipment of sufficient size or power, and their movement over imperfectly constructed lines. In 1838 the average charges on 8 of the principal roads in this country, was about 7 1-2 cents per ton per mile, the lowest charges being on the Baltimore & Western, 4 cents, and the highest, Boston & Providence 10 cents, the striking contrast of these figures, showing a very bad management or enormous profits to the Transportation Companies. The State of Penna. after careful and close calculation in the same year, came to the conclusion that 12 mills per ton per mile would cover all expenses for a train of 20 cars loaded, transportation costing 8 mills, leaving for supervision, maintenance and repairs 4 mills. It was due to these excessive charges at this time, that the New York Legislature going deeply into this important question, decided very incorrectly, (for there were lobbyists in the interests of contractors, who exaggerated and padded reports of roads unfavorbly located,) that cheap transportation could never be expected from Railways, which thereby stimulated the development of the construction of Canals which lasted until '62.

However, as all revolutions whether arising from an economic or political emergency, seem to create men able to grasp the situation and with conspicuous energy and self-reliance, demonstrate facts to a straddling community, one appeared in this instance in the person of Mr. J. Edgar Thompson, Chf. Eng. of the Ga. Ry. & Bnk. Co. This line had been constructed under his management, and had in 1840 begun a prosperous career. In his annual report Mr. Thompson made use of the following, which at this time exercised a marked influence, and has added no little to immortalize his great and successful career. He said, "I can now state with confidence, that whenever the Transportation is of a mixed character such as agricultural products, general merchandise and passengers, sufficiently large to justify the construction of a good road, Railroads will be found to be not only the most expeditious, but

cheapest artificial medium of conveyance at present known." Had his remarks invited the close inspection and scrutiny into the great interests involved, which even at that time they seemed to merit, an immense waste of the peoples' money could have been saved and applied as it afterwards was to the careful construction of railways. The extent of the enormity of this outlay is realized, when we face the fact that the aggregate length of Canals abandoned in 1880, was 1953 1-2 miles and had cost $45,013,166, or $22,529 per mile, which if judiciously expended would have built at that time about 3500 miles of Railroads. Instead, however, it seemed to stimulate the development of the water-ways, which resulted in bitter rivalry, the end of which we are all familiar. We must not here lose sight of the tremendous construction of Canals as a factor for cheapening rates, but the fact that they were cheapened and the substantial existence and financial success of Rys., well constructed, favorably located, and ably managed, mark a great epoch in Industrial Triumphs. As canals are a thing of the past, I will not devote any time upon discussing their causes of failure, but deal with the rapid development of our Railroads.

There was at the close of 1850, 8590 miles of railways in operation in the United States, representing an aggregate cost of $296,660,148, or an average of $34,539 per mile. Average cost grouped as follows:

In the New England States the cost per mile was about								$40,000.
" " Middle Atlantic	"	"	"	"	"	"	"	48,000.
" " South Atlantic	"	"	"	"	"	"	"	23,000.
" " Gulf	"	"	"	"	"	"	"	18,500.
" " Interior	"	"	"	"	"	"	"	20,000.

Taking into consideration the character of countries traversed in the different sections above represented, and the cost of labor and material, there seems but one conclusion left to us, viz:, while the pioneer was struggling for a new home and the South was investing in slaves and picking cotton, the shrewd unscrupulous speculator was plucking the earings and savings of all whom he could get to buy his watered securities. In the early history of the American railways enterprises the most popular custom of providing means for their construction, was for the respective states to advance loans or obligate themselves for a funded indebtedness; but no few were built with stock or personal subscriptions, this being the case in some of the more important New England roads and the Pennsylvania railways. And it may be remarked here, that whenever the people subscribed for a public enterprise, and what seemed a common necessity in which all were interested in a general rather than an individual way, and the money raised was sufficient only for the purposes intended, the results have been wonderfully satisfactory.

Shortly after 1850, ideas were advanced, that, after half the cost of

a road had been contributed by States, Counties, Cities etc., or by bona-fide stock holders, it was a prudent policy to issue Bonds to cover the remaining cost: this tendency of lessening the degree of fidelity, with which the full amount of capital stock was paid into the treasury of Bonded Companies, the loss to the unfortunate investor has been the result, in too many cases, and caused the failure of many enterprises.

The policy adopted by the several states, promoted for the most part by unscrupulous politicians, who had only the one end to meet, (that of personal remuneration) proved conspicuously disastrous, (with perhaps one exception, the State of Michigan,) Illinois narrowly escaping bankruptcy, and ending finally with a debt balance of $6,000,000 for her experience. Notwithstanding the excessive strains under which the roads were operated in the 5th decade, due to financial panic of '37, collapse of state credit and inadequate means, they were as a rule profitable to their promoters, paying from 5 to 20 per cent. dividends on their stock. These favorable figures seem particularly significant, as a result of earnings from short lines, which continued to do remarkably well during their independent existence. As for example: a trip from Albany to Niagara Falls in 1849, a distance of 348.7 miles was accomplished by traveling over 8 independent lines, the largest of which was 78 miles and the shortest 16.9 miles. The lowest net revenue on the cost, being 62 per cent. on the Albany & Schenectady, which cost $94,985 per mile, the highest on the Utica & Schenectady, 16.4 per cent. on a cost of $41,384: the average for the total mileage being 12.2 per cent, while on the other hand, the New York & Erie completed about this time, represented 483 miles, proved a Waterloo for its promotors and investors. As a comparative result, between transportation at this time over rail-ways and earth roads, I find a government official document written in 1852 gives the following table; showing the limited space over which wheat and corn can be transported as compared with railways at 1½ cts. per ton per mile.

Mr. Henry C. Carey published a statement of Passenger Fares, Jan'y., 1848, embracing every line in the union, north of Baltimore and east of Ohio, except the Camden & Amboy, in which the average fares charged, was only 2.85 per mile, the average for first class fares in the United States being 3.6 cts. per mile and the average cost of all freight movement, including 1st. & 2nd. class, being 7.56 cts. per ton per mile.

From 1850 to 1860. The wonderful progress of construction in this period marks an epoch in the history of Transportation facilities of the country; before 1860 the amount of traffic by water exceeded that of rail; after it was radically changed, and has since continued to grow largely in favor of the cars. In 1860, the railway mileage in the U. S.

VALUE PER TON AT MARKET.*

	TRANSPORTATION BY RAILWAY @ 1½ CENTS PER TON PER MILE.		TRANSPORTATION BY ORDINARY HIGHWAYS.	
MILES TO MARKET.	WHEAT.	CORN.	WHEAT.	CORN.
	$49.50	$24.75	$49.50	$24.75
20	49.20	24.45	46.50	21.75
40	48.90	24.15	43.50	18.75
60	48.60	23.85	40.50	15.75
80	48.30	23.55	37.50	12.75
100	48.00	23.25	34.50	9.75
150	47.25	22.50	27.00	2.25
300	45.00	20.25	4.50	

*Wheat, $1.50 per bushel. Corn, 75 cents per bushel.

had increased from 8,589 miles in 1850 to 30,793, and swelling the cost of constructionfrom $296,660,148, to $1,151,560,829, a tremendous absorption in one industry.

This era will ever be noted for the completion of the links between the principal Eastern seaboards and the Great West. Particularly with lines as far as the Mississippi River which either crossed or flanked the great barrier, the Allegheny Mts., as well as parallelling the water-way. It was during this period that some of the great trunk lines west of the Mississippi had their birth, the C. & A., C. B. & Q., C. M. & St. P., C. & N. W., C. R. I. & P., Ill. Cent. & Wabash,—all were operating lines from 220 to 705 miles in length.

As the result of the enormous increase to our mileage in the 6th. decade, we had two panics, 1854 and 1857, and created a very bitter and permanent competition between rail and water companies; the popular theories of the panics being the large sums invested in unprofitable lines, delays in securing Legislative authority to raise funds on 2nd. Mortgage Bonds, and hostilitities in Europe. The tendency to construct Roads on borrowed capital and solicit subscriptions of cities and counties began to be such a source of evil, that some states prohibited it. And Railroad building has drifted as a result of these evils into a financial, not a mechanical profession, in other words, how much can the promotor manipulate for himself, not what the engineer says,

it can safely earn on an economic construction. I venture to say if every railroad that had a speculative element in it had been prohibited as it should have been from the start, we should have had many miles, less, scarcely any that would not pay well for the money invested, and still had ample for our increasing wants.

The substitution of T for Edge rails and Coal burning Locomotives for wood burners, were also features of the 6th decade. Taking the Pennsylvania Ry., as an example of a well managed Road, during this period the tonnage and average freight rate is represented as follows:

1855	Tons	moved	1	mile	102,171,312—frt.	per	ton	per	mile	2.746	ct.
1859	"	"	1	"	180,333,140	"	"	"	"	2.027	".

Showing a material decrease in rates each year.

The dividend earning roads were mostly confined to the New England, Atlantic & Trunk Lines of the N. W.

7th Decade, 1860 to 1870.

Owing to internal strifes and the great demand for money for war purposes, this is the first period in the history of American construction when a greater addition to its mileage was not recorded over the previous decade. The amount being 16,090 miles against 20,109 for the 10 years ending with 1859. The total cost of the 48,860 miles of railroads in 1870 was $2,212,412,719 or $45,231 per mile; the highest $51,679 in the Middle Atlantic States, and lowest $24,129 in the South Atlantic. While some connecting lines had consolidated prior to 1860, it was during the 7th decade, that it became a marked and almost leading feature. The commencement of substituting steel for iron rails, thereby permitting heavier equipment, was a leading and permanent improvement in this decade.

8th Decade, 1870 to 1880.

Mileage constructed 41,452. Total in U. S. 84,964 miles. This period not only exceeded that of any other, but formed nearly half of all the mileage in the country up to that time.

The most important stimulus during this time was the general abandonment of the custom of calling for stock subscriptions for a large portion of the cost, the willingness of Europe to take the Construction Companies Bonds, and the desire for competing lines, which induced many states to enact free Railroad laws, widening the fields for speculation. The famous panic of 1873, largely retarded the construction of lines in this decade, probably cutting down the mileage several thousand. It was during this decade popular antagonism to land-grant roads, crystallized into hostile legislation; which, coupled with fierce rivalries and the Jay Cooke failure, forced many roads into receiverships and bankruptcy.

The great evil arising from the over capitalization of many roads

is shown in the fact, that in 1870, the dividend earning capacity of 44,-614 miles operated, with a capital and funded debt of $2,664,627,645 was a very trifle over 2 per cent. which decreased in '77 & '78 to a trifle over 1 per cent. on the capitalization, and in 1880, 92,146 miles representing $4,897,401,907 paid dividends only of 1 59 per cent. When it is understood that nearly 2.3 of the aggregate in ton miles was performed by only 28,693 miles of road located in N. Y., Penna., Ohio, Michigan, Indiana, Maryland, Delaware & New Jersey, and that the number of tons carried daily over the entire length of road in this group, averaged 975, as against 41 to 325 in other sections, the fact is clear that those investing in western and southern securities had unbounded confidence in the rapid developments of those sections, and that the above mentioned group received only 1.02 cts., per ton per mile on freight, and 2.21 cts., for passengers carried in 1880, they paid as a rule larger dividends than roads receiving 50 and 100 per cent. more freight, even when the lines were well located. We must not lose sight of the great efficiency and comforts of travel effected in this decade by the advent of the Westinghouse Air Brake, the general adoption of steel rails, heavier and better equipment, which enabled more speed and heavier trains with less danger, and the use on Trunk Lines of Pullman and Wagner sleepers.

9TH. DECADE FROM 1880 TO 1890.

If the 8th. Decade caused us to look with wonder, the progress of the development in the 9th. is truly astonishing, there being on June 30, 1890, 163,597 miles completed railways, an increase of 78,633 miles or nearly one half of all the mileage in the country, repeating again the same ratio as between 1870 and 1880: shall we not conclude here, in face of these figures, we have probably reached the maximum of the development of this great industry in any one decade, and like the development of the great kindred industry "Iron", pause awhile to catch up?

We are all familiar with the principal features of this decade bearing on Railroads: how the sharp competition and general tendency to cheapen rates (which seemed long enough before) have been met by the managements, with Traffic Associations, pooling agreements, and consolidation of parallel and competitive lines; and, combatted by the public through State and Government Commissions in which both just and unjust laws have been enacted, as a safe-guard to what the citizen deems dangerous monopoly. The question, "Are our Railroads Profitable?" is conclusively answered by the Report recently published by "The Inter State Commerce Commissions," which shows for the year ending June 30, 1890, 156,404 miles of road paid in dividends $89,688,201, on an actual capitalization of $9,437,353,-372 or 95.100 of 1 per cent.; whereas if the roads were capitalized for their earning capacities on a basis of 5 per cent. to the investor the

above mileage would be valued at $6,627,461,681. The actual capitalization of Roads represents $60,681 per mile. Can any one doubt of the ability of this amount per mile to earn an honest dividend? And shall we ask for further reasons for hard times when we have such an enormous sum earning nothing for the investor?

General Horace Porter in a letter to the North American Review for Dec., '91, is authority for the statement that "the average passenger rate per mile has fallen from over 3 cents in 1870 to 2.12 cents, in 1890. The average freight rate per ton per mile has fallen in the same period from over 2 cents to .93 cents (this is exclusive of excursion and commutation rates, which if included would bring the figure to something like ½ cent per mile.) It may be interesting here to show a comparison of rates with European Countries.

	Class.		
	1st.	2nd.	3rd. class
United Kingdom......	4.42	3.20	1.94
France...	3.86	2.88	2.08
Germany............	3.10	2.32	1.54
United States.........	2.12		

The freight rates in U. S. are about 5–8 of those charged on the continent of Europe, and a little less than half of those which prevailed in Great Britain.

There seems but one opinion from those who have felt the pulse of the great money centers abroad, that if a uniform remunerative rate could be maintained, the favorite investment of all would be American Railway Securities, in stocks (as well as bonds) where roads have issued them on a fair basis of their earning capacities, or actual cost. The tendency has unfortunately been to discount the future, and the trying emergencies of the last few years has been a bitter lesson and example of the evils arising from inflated values, which has caused stocks to greatly decline, resulting in Europe sending back our securities in place of giving us gold for our cereals, of which she so largely bought this year. The only consolation of which is, we may be able to carry them, until such a time that, owing to their better showing, we may sell them back at a good profit, and invest the surplus in new and heavier rails, equipment and general betterments which the emergencies of this decade demand. It is to be regretted, that while the rolling stock is doubled in capacity and weight, the road bed has by no means kept pace with it, and I am quite certain the large percentage of accidents lately, is due to this more than any other cause.

Having completed a brief history of the greatest industry this country to-day possesses, and the most vital as to the necessities and comforts of the people, let us reflect on the results as they appear to-day.

There is much to be said in favor of the combination as it now exists;

through rates, and cars without change, insuring rapid transit, increased responsibilities, which has produced more cautious policies, and as a result cheapening of rates, are all strong arguments in its favor. But the fact that the people are in arms against it and will force the issue at no distant day, dooms it. The dissolving recently of the Standard Oil Co., the Beam Combination, and the heavy pressure now brought to bear on the sugar, whiskey and like associations, will make their disruption only the more disastrous and conspicuous the longer they maintain the fight. Michigan has ever been noted for her promptness and activity in adopting measures bearing directly with the common necessities of her citizens, and at a meeting of the State Grange there last December, it was recommended that a road be declared insolvent and a Receiver appointed, whenever the value of the road is exceeded by 50 per cent. of the outstanding Bonds and the face value of Stock issued, and to prevent future over capitalization, it is suggested the Commissioners supervise the issue of Stock and Bonds, and limit the face value of the Stock to the estimated cost of road and equipment, and require the tariff schedule to be lowered whenever the annual earnings of the road exceed 6 per cent. of its stocks and bonds.

"In the review of current events preceding a sermon in Association hall, New York, March 13, Rev. Thos. Dixon discussed the question of the governmental control of Coal & Iron Industries, he said: "Among the recent decisions of the supreme court of the United States of far reaching importance, is the one affirming the legality of the grain elevator statute of New York. This law regulated the price of elevating and storing grain. It was attacked on the ground that such a regulation was an unconstitutional interference with private business. The supreme court holds that any business affected with a public interest is subject to the regulation or control of the state, and that elevating grain is a business of this kind.

A JUST DECISION. This is a dishonest progress in the history of the role of government in the world's commerce. The supreme court has risen to the occasion of a new century's needs and rights in this just decision. We do not pretend to say that for a moment we believe that our fathers dreamed of such a law being possible under the constitution they made. Neither did they dream of many other things that have come to pass of the necessities of a new life and a new civilization under that constitution. This principle, as affirmed by the highest judicial tribunal of the world, is the entering wedge of the social revolution toward which we are being driven with resistless power. There can possibly be no limitation to its application at last to every business that touches the public life, linked either as cause or effect to the co-operative energy of the community.

FAILURE OF PRIVATE CONTROL. More and more is society forced to

pronounce the management of its public business by private power a failure, and a menace to the life of the community. The railroad problem has created the interstate commerce commission, which is a temporary and ineffectual make shift between private ownership and ultimate governmental control".

If you bond your house, farm or any personal or real property for what it cost, do you suppose you could find an idiot stupid enough to loan you the amount on stock based on its earnings capacity, which scarcely pays its funded obligations? Such things cannot exist except in rare cases, why is it more reasonable for the people to be asked to pay railroads on their enormous padded capitalization? They won't do it, and the next step will go farther than the recommendation of the "Michigan Granger", and limit the earnings to 5 or 6 per cent on the cost of construction, which is as it should be. It is hard to say just how much further the public will be blinded in this matter, and when the issue comes, it is sure to be decisive, and no amount of doctoring or evasions will avail, once the tide turns. There may appear serious objections to us now, in popular or government control of such a vast enterprise, but when the harness is tried we will find like all other measures for the good of the whole people, it will adapt itself to our needs and wants, and there will still be very much need of able Railway managers, who will not be selected for their abilities of borrowing millons. We have built, borrowed and developed our country at a rate unheard of in civilization, we must pay back and weed out and economize, we are deeply "in it" now, and most of us praying for the end which does not come.

We of the west, have justly earned the reputation of energetic and industrious citizens, and as a rule are entitled to it. There is no question about our energy, nor does there seem to be any limit as to our ambition; our gold line is placed so conspicuously high and prominent, that it seems little less than that a miracle must be performed to bring even a few of us within its outer lines, or place us in a position to see only the unfinished splendor of the great undertaking as planned and outlined by the architects of this decade. Whatever the channel to be spanned, or difficulties that may be encountered in attaining a desired result, there seems little to fear that the ingenuity and perseverance of the Engineer will not supply directly the want is felt. Measuring his attainments by the wonderful achievements of the last score of years, we shall doubtless in the next, need neither mule, boat or locomotive to aid transportation of body or products, but on downy cushions amidst sunshine and clouds, in warm or cool latitudes, at our will, without the interference of Railway Commissioners, peacefully construct our own air-way on lines laid out and projected at will, in which shall appear no reverse curves or heavy grades; then may we

hope to have taken from the millionaire speculator his mace and jimmy by which means he has forced the too insecure vaults of the peoples' wealth, and with grappling hook and telescope dredge up the sunken wrecks and fly with them into a new era of regeneration and prosperity, based on level lines, just and equal administration: the ticket for passage bearing the stamp "This is a man."

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

BOSTON SOCIETY OF CIVIL ENGINEERS.

April 25th 1892:—A regular meeting was held at the Rogers Building, Massachusetts Institute of Technology, Boston, at 19:45 o'clock.

Thirty-eight members and seventeen visitors present.

President Henry Manley on calling the meeting to order, spoke substantially as follows:

In assuming the duties of the office to which you have elected me I desire to return my most grateful thanks for the honor conferred. The election to the highest office in the gift of this large and powerful organization of Civil Engineers is no light honor. I appreciate it fully, and say frankly that I am very proud of it.

The Society is in sound financial condition, no member of it is in arrears for dues. We have accumulated funds amounting to between four and five thousand dollars, and no debts.

Our resources for professional papers are large. From our members and from gladly helping friends we can draw the best and latest information upon every variety of engineering work, and the best and latest results of scientific investigation and discovery in all allied branches of Science.

Our greatest and most pressing need is a Society home. I believe that the time has come for this matter to be taken in hand in earnest. I believe that the resources of the Society, and the individual resources of its members, fully warrant us in immediately taking steps to that end.

Gentlemen, the Boston Society of Civil Engineers has come to Boston to stay, and it wants a house to live in. Shall it have it?

The record of the last meeting was read and approved.

Messrs, Harry B. Burley, Charles W. Gay, William S. Johnson, Frank M. Sherman, and Frank E. Winsor, were elected members of the Society.

The Secretary reported for the Board of Government that it had voted to continue the several special committees of the Society and had selected the membership thereof as follows:

On Weights and Measures:—A. E. Burton, L. F. Cutter and H. A. Phillips.

On National Public Works: W. E. McClintock, L. F. Rice and Sidney Smith.

On Highway Bridges:—J. E. Cheney, D. H. Andrews and E. S. Shaw.

On the Library:—F. W. Hodgdon, S. E. Tinkham, H. D. Woods, X. H. Goodnough and J. H. Stanwood.

On Excursions:—J. R. Freeman. F. P. Spalding, G. T. Sampson, F. V. Fuller and F. W. Dean.

The Secretary submitted for the Board of Government the following recommendations and upon motions they were severally adopted:—

That the sum of $200, expended from the permanent fund for current expenses, be restored thereto from the current fund.

That the Treasurer be authorized to deposit the funds of the Society with the Old Colony Trust Co.

That the President be authorized to appoint a committee of three to aid the Massachusetts Commission, World's Columbian Exposition in securing a creditable exhibit in the department of civil engineering.

The President appointed as the committee, Messrs. J. R. Freeman, Fred. Brooks and H. D. Woods.

Mr. E. P. Dawley, Chief Engineer, N. Y., P. & B. R. R., was then introduced and read a paper prepared by Mr. J. A. McNicol, C. E. of Providence describing several forms of solid or ballast floors for bridges. Mr. Dawley supplemented the paper with a very full account of the railroad bridges recently built on the N. Y., P. & B. R. R., and exhibited a large number of photographs of the work.

Mr. Albert H. Howland read brief extracts from a paper prepared by him on portal bracing for bridges.

Mr. James H. Stanwood submitted a straight-line formula for calculating the strength of yellow-pine posts and compared it with the common formula in use.

After passing a vote of thanks to Mr. Dawley and Mr. McNicol for their interesting papers, the Society adjourned.

S. E. TINKHAM, Secretary.

MAY 18TH 1892:—A regular meeting was held at the Rogers Building, Massachusetts Institute of Technology, Boston, at 20 o'clock.

President Henry Manley in the chair.

Forty-six members and fourteen visitors present.

The record of the last meeting was read and approved.

Messrs. Loammi F. Baldwin, William B. Fuller, Horace G. Holden and George C. Whipple were elected members of the Society.

The President announced the death of Mr. M. G. Grant, a member of this Society, which occurred May 10, 1892. On motion of Mr. Howe, the President was requested to appoint a committee to prepare a memoir.

The President appointed Mr. Thomas Doane.

The Secretary read a memoir of Sophus Haagensen prepared by Messrs. Lawrence Bradford and T. T. Hunter Harwood, a committee of the Society.

On motion of Mr. Fuller it was voted: That the thanks of the Society be extended to Mr. J. R. Kendrick, General Manager of the Old Colony Railroad, also to Messrs. E. P. Dawley, G. B. Francis, W. D. Bullock, J. V. Dart and other engineers of Providence associated with members of the Society, for courtesies shown on the occasion of its excursion to Providence, May 18, 1892.

On motion of Mr. FitzGerald it was voted:—That the Secretary be authorized to procure an album in which to place the portraits of deceased members of the Society.

Mr. Francis W. Dean was then introduced and read a paper on Compound Locomotives.

Mr. James H. Stanwood exhibited a number of specimens taken from bridges and other iron structures showing the injurious effect of rust and gave an account of various paints and other preparations which have been used to prevent this corrosion.

Adjourned. S. E. TINKHAM, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

365TH. MEETING, MAY 6TH 1892:—The club met at 8 P. M. at the club rooms. President Johnson in the chair, and 22 members and 3 visitors present.

In the absence of the Secretary, Prof. Wheeler acted as Secretary pro tem.

The minutes of the 364th meeting were read and approved.

The paper of the evening was then read by Prof. C. C. Brown of Union College, New York, on the "Pollution of the Hudson River."

Prof. Brown premised his remarks by saying that an extensive series of chemical biological examinations had been started, and though much work had been accomplished, it was premature to put his paper into print, until additional samples had been collected and examined.

By the aid of maps, he illustrated and described the drainage basins of the Mohawk and Hudson Rivers, and called special attention to the population along their banks, giving sizes of the towns and cities and whether sewered or not. Called attention to the density of population following the drainage systems of the state, illustrating it by an average population of 2 per sq. mile in one of the inland counties, and 321 in Albany County. Also that the Census returns showed a quite rapid increase in the towns and cities, and a decrease in the farming districts and small villages. Therfore that river pollution would increase at a more rapid rate than that due to the growth in population in the cities that are usually found on the banks of the streams, from the contamination due to the development and growth of factories due to such urban growth.

That the pollution of the Hudson River not only affected the towns and cities along its banks that derive their water supply from it, but also affect the 3,000,000 tons of ice that are usually harvested into the ice houses that line its banks from Poughkeepsie to Troy, as freezing does not entirely eliminate the contamination.

A geological map was then exhibited showing that the drainage basin of the Upper Hudson was in the older Paleozoic and Archaean formations, and hence the water was soft, while the Mohawk was largely in the Heiderberg limestone formation, and consequently very hard from mineral matter.

Stated that samples had been taken from the Mohawk River from above Utica, where it is free from contamination, to its mouth at Albany, the samples being collected with special reference to the towns and cities on its banks, to show their influence.

That another series of samples had been taken from above Troy, where the Hudson River is free from contamination, to some 15 miles below Albany.

One series of samples from each river was taken during the summer, and another series in the winter, from the ice covered surface, while the samples were taken at a depth of 8 to 10 inches below the surface. The biological samples were taken at ¼ distance from each bank and were plated on the same day as collected. The chemical samples were so taken that 25 per cent., was taken at ¼ distance from each bank and 5 per cent. from the middle of the river, and the summer series were examined the same day they were collected while 2 to 3 days intervened in the winter series before they were examined.

In the case of the Hudson River series below Troy, one set of samples

was taken on the flood tide, and one set on the ebb tide to show the affect of tidal influence.

The results of the biological examination of the samples was to show a very decided and persistent increase in the number of bacteria per cubic centimeter after the entrance of the sewage from the towns and cities, which would decrease as the river passed below the source of pollution, to again rise rapidly on receiving the sewage of another city lower down. In the case of the Mohawk, the number of bacteria was 200 to 250 per 1 *c. c.* in the summer, above the source of pollution, and increased to as high as 37,000 at Utica, while 5 miles below Utica it had decreased to 2,000.

The Hudson River series of samples showed in a similar manner the contamination of the river by sewage in the rapid increase in the number of bacteria, which amounted to 200 to 250 per cubic centimeter above Troy, where the river is pure, to a maximum of 35,000 when most affected by the sewage of Albany.

It was found that the quantity of bacteria is very much less in winter than summer from the lessened action by oxidation as the river surface is so largely covered by ice. Also, that the influence of rapids, water-falls and other ozidixers, is to temporarily increase the quantity of bacteria present.

It was found that it is extremly important to collect biological samples only when the water is clear, as when muddy or contaminated by land-wash, the number is very greatly increased by the bacteria washed off the surface of the land and hence not due to the influence of sewage.

It was thought that the biological method is the only safe and reliable method of examining for polluted waters, though mere quantity of bacteria does not necessarily mean danger, as the real risk depends on the kind of bacteria present. But thought that large numbers predispose towards dangerous kinds of bacteria, but as the determination of species is very difficult and tedious, thought that the much easier and more rapid method of obtaining numbers only as being sufficient to indicate the character of a water.

Regards the chemical examination as inconclusive, as he found that the chemical samples at times contradicted the biological examination though on the whole there is a more or less coincidence between the number of bacteria and the amount of free and albuminoid ammonia.

Thought that river purification is largely due to dilution and sedimentation, as the bacteria constantly tend to settle to the bottom of the stream and become inert.

It was thought that ordinary river pollution will purify itself in 5 to 10 miles below the source of contamination, if the dilution is reasonably large due to the volume of the river.

The paper was discussed by Messrs. Ockerson, Seddon, Russell, Johnson and Wheeler.

Adjourned. H. A. WHEELER, Secretary, pro tem.

366TH. MEETING, MAY 18, 1892:—The club met at 8 P. M., at the club rooms, President Johnson in the chair, and 16 members present. The minutes of the 365th. meeting were read and approved. The Executive Committee reported the doings of its 131st. meeting. After discussion, the report on the question of subscribing to engineering papers was laid over for future action.

In the absence of the author, Mr. Turneaure read Prof. Howe's paper on the "Maximum Stresses in Draw Bridges." The paper discussed the various loadings possible for draw bridges, under different conditions: then took up the case of a draw bridge of two equal spans acting as a continuous girder and subjected to equal panel concentrations. The panel points which should be loaded to produce the maximum moment or shear at any point, was found by the aid of a diagram having plotted on it curves giving position of zero moment, amount of moment at turntable support, and amount of end reaction, for a concentrated load at any point. Only four different loadings were found to be necessary, and knowing these, four corresponding equilibrium polygons were sufficient to determine the maximum positive and negative shears at each panel point. The web stresses were determined by taking from the diagram the end reactions due to the panel loads applied in each case, and with the combined reaction, compute the web stress as in a discontinuous span.

For unequal concentrations, the best method would probably be to compute the moments and shears for each panel for each load and then distribute the concentrations as nearly as possible according to the magnitude of these moments and shears.

For actual wheel loads the computation would be very complex. Instead of wheel loads, an assumed equivalent uniform load or a uniform load and an engine excess would give stresses nearly correct.

Discussion followed by Messrs. Johnson, Hubbard and Pegram.

Prof. Johnson exhibited an apparatus designed by him and constructed by Mahen & Co., St. Louis, for measuring the elongation or compression of test specimens while under stress. It consists of two collars fastened to the specimen by set screws, each carrying a graduated circle four inches in diameter, over the face of which moves a balanced pointer. This pointer carries a small vernier and is attached to a spindle, in which is a friction roller measuring exactly one-half inch in circumference. The roller on one spindle is operated by an arm which is attached to the other collar, these arms being mounted symmetrically on opposite sides of the specimen. The apparatus reads with exactness to the nearest one-ten-thousandth of an inch, and registers elongations beyond the elastic limit as readily as it does those below that limit. Its operation is very satisfactory.

Adjourned. ARTHUR THACHER, Secretary.

367TH. MEETING, JUNE 1, 1892:—The club met at 8 P. M., at the club rooms, Vice-President Crosby in the chair, and 20 members and 3 visitors present. The minutes of the 366th. meeting were read and approved. The Executive Committee reported the doings of its 132d meeting.

Upon motion, it was decided that the club subscribe for the Engineering News, Engineering and Building Record, Railroad Gazette, Railroad and Engineering Journal, Journal of the Franklin Institute, Electrical Engineering and the London Engineering.

Mr. Flad presented some diagrams showing loss of head for the flow of gases through pipes of varying diameters and for varying velocities. Discussion followed by Messrs. Wheeler, Colby, Flad and Love.

Mr. Ockerson exhibited blue print diagrams showing the effects of erosion on the Mississippi River banks, from Cairo to Donaldsonville, from 1877, 1883 to 1892. The diagrams showed graphically the annual

amount of caving per mile of river considered in sections of ten miles. Discussion followed by Messrs. Colby, Wheeler, Flad and Crosby.

For the next meeting, September 21st, a paper on the "Methods and Results of Precise Levelling," by Mr. O. W. Ferguson, was announced.

Adjourned. ARTHUR THACHER, Secretary.

WESTERN SOCIETY OF ENGINEERS.

292ND. MEETING, JUNE 1, 1892:—The 292nd. meeting of the Society was held at the rooms of the "Central Traffic Association," The Rookery, Chicago, Wednesday evening, June 1st., 1892 with some 25 members present. President Isham Randolph in the chair.

After the call to order, the President announced that before entering upon the work of the evening, Gen. Sooy Smith wished to make a personal explanation.

Gen. Wm. Sooy Smith said: It will be remembered by you that sometime ago, before the report on the Railway Problem was formulated and presented to the Society, a report by Mr. Corthell on a portion of the work of this committee was published by a daily paper in Chicago,—much to the surprise of the committee, and also to their regret, as unpleasant impressions were likely to be formed; and so the matter was considered by the committee, and it was concluded, as Mr. Corthell was absent, that in justice to him all action with regard to it should be postponed until his return. The result proves the wisdom of that course; for, unpleasant impression once getting abroad can never be thoroughly corrected. Many who see the thing which has produced such an impression, fail to see the explanation, and so the unpleasant impression remains.

In this case I have an explanation to make which fully exonerates Mr. Corthell, and if any blame is to be attached to any one in that matter, it belongs to myself. To make it still more plain to you I will state, that at one of the meetings of the committee called to formulate the report, it was suggested that each member should write a report, and those reports should be brought together and consolidated. I suppose this report of Mr. Corthell was written in accordance with that suggestion. One day a copy of Mr. Corthell's report was handed to me for my information. I put it in my pockets and carried it for some little time for the purpose of reading it at such odd times as I could get, and one day I fell in with the Commissioner of Public Works of the city. He said he was greatly concerned in the question discussed by this committee, and also to be discussed to-night by the Society, and said that he was very anxious to know something of the result of the investigation of our committee. I told him that the committee had not yet formulated its report, but that one of the members Mr. Corthell, had written a report of the investigation, and that I had it with me to look over for my own information, and he wanted to know whether I would give him a copy of Mr. Corthell's report, and I said to him that the committee had not yet adopted it, and that I only had it for my own information. He said that he would like to look it over with the City Commission, with the understanding, of course, that it was to be a perfectly confidential thing. He said "I supposed, and still suppose, that one of the best effects or results of the deliberation of that committee is that which it will have upon the city," and in pursuance of that idea, I passed the report to him in that way, he promising to return it to me in a day or two. He tells me that he put that report in a pigeon-hole in his

desk and then was called away for a day or two, and the deputy finding it and thinking it belonged to the papers of this City organization, placed it among their papers, and it got into the hands of a reporter and so was published.

I do not see that it was the fault of any one; certainly not Mr. Corthell's. If any one is to blame it is certainly myself, in handing it to the Commissioner of Public Works at all.

General Smith then went on to explain his remarks appended to his signature printed in the report. With regard to the appointment of such a Committee he did not think it consistent with the best interests of the profession that the Society should appoint committees of those members able to treat such important subjects exhaustively, and expect them to do so without compensation. It should not be expected of members to do such work for the public gratuitously.

Speaking of his criticism of the Report, after his signature, he regretted and withdrew his remarks except as to his conviction that reports of this kind should not be undertaken by organizations such as ours for reasons stated.

The regular order of business was then called for. The reading of the minutes of the previous meeting was dispensed with. There was no report from the Board of Directors but the Secretary announced the following applications for membership on the file: Edgar S. Nethercut, Lee L. Dagron.

The Secretary read a communication from Mr. F. Collingwood, Secretary American Society of Civil Engineers, notifying the Society that the American Society had accepted the duty of organizing and conducting "Division A" of the Engineering Congress, World's Congress Auxiliary of the Chicago Exposition, and asking the Western Society of Engineers to name a member to aid the Committee in certain work.

The communication was referred to the Board of Directors with power to act.

The Secretary also announced that the American Society had sent invitations to our officers to attend the Annual Convention—at Old Point Comfort, Va.

The President announced that the Committee on Badge, Seal, etc., would report at the summer meeting.

A contribution to the discussion on "An Enlarged Water-Way between the Great Lakes and the Atlantic Seaboard," from Mr. Wm. Pierson Judson, of Oswego, N. Y., was then read. (The paper will be put in type as soon as possible.)

Mr. L. E. Cooley followed and warmly advocated that any assistance that could be given by the Society should be given Mr. Judson, so that an appropriation might be made to enable at least a thorough investigation of the route suggested by Mr. Judson to be carried out.

Mr. Jas. J. Reynolds moved that the discussion of the Report of the Committee on the "Railway Problem of Chicago" etc., be postponed for two weeks and be taken up at a special meeting.

Carried and a special meeting was ordered for the discussion, to be held on Wednesday evening, June 15.

The President announced that the officers of the B. & O. R. R. had very courteously tendered a train for the use of the Society for the day of the Summer Meeting.

The Secretary was authorized to accept the offer and to convey the

thanks of the Society to the officers of the B. & O. for their kindly consideration.

A motion was then made and carried that a Summer Meeting be held and that the President appoint a Committee of three to arrange a programme, and provide for the occasion.

Mr. L. E. Cooley then rose and spoke at length in opposition to the views expressed by Gen. Sooy Smith on the question of the work of the Committee on "The Chicago Railway Problem." As he was in a measure responsible for the appointment of the Committee, and as the Society had by a large majority vote supported him, he felt it his duty to defend it and presented many arguments in favor of Engineering Societies taking prompt action in all public matters calling for engineering labor, around which action, concentrated effort might crystallize and thus force conclusions years before any results might be obtained by the "laisser aller" policy so usually pursued.

The President announced the Committee on revision of "Constitution and By-Laws:" Thos. Appleton, L. E. Cooley and Fremont Hill.

Adjourned. JOHN W. WESTON, Secretary.

ENGINEERS CLUB OF MINNEAPOLIS.

MAY 21, 1892:—The second joint meeting of the Engineers' Club of Minneapolis and the St. Paul Society of Civil Engineers, took place Saturday May 21st. The members of the two clubs were the guests of the Gillette-Herzog Mfg. Co., of Minneapolis and met at the shops of said firm at 3:00 o'clock P. M., spending the afternoon inspecting their new bridge shops and the foundry, afterwards some of the members visited the Flour Mills and some, the Falls of St. Anthony, which were very fine, due to the high stage of water in the Mississippi.

At 7:00 o'clock, some fifty members and guests met again in the rooms of the Builders' and Contractors' Exchange, where they were handsomely banquetted by the Gillette-Herzog Company. After dispensing with the routine business, Mr. Wilson of St. Paul read a paper on caves and tunnels in St. Paul, stating that although the location of St. Paul is much diversified and broken, only one railroad tunnel, that of the Northern Pacific Railway has been constructed, but that in the portion of the city which runs from the State Capitol to Fort Snelling, and from the river to the bluff, a great many tunnels for sewers, water mains and telephones are located.

The geological formation of said district is Trenton limestone twenty (20) to thirty (30) feet thick overlaying the so called St. Peter Sandrock. This Sandrock is soft and can be picked and shoveled and permits of easy tunnelling.

There are about twenty (20) miles of sewer tunnels, three (3) miles of water works tunnels, and three-fourths ($^3/_4$) mile of Telephone tunnels; but besides these artificial tunnels, there are several natural ones, of which the two (2) most noted ones are:—

The so called Carvers Cave discovered in 1766, by Jonathan Carver, and which was an object of great interest to the early settlers, being 150 feet deep, 30 feet wide and 15 feet high, with a pool of water in it remarkable for its clearness. The entrance to this cave has been blocked by the construction of the C. B. & N. Ry.

The other cave is Fountain Cave, first mentioned by Major Long in

1817. It is much larger than the other, the entrance is 25 feet wide, 20 feet high and 1,300 feet long.

Eight establishments (principally breweries) have large artificial storage vaults in this rock, some extending as far as 1200 feet in length. In the before mentioned Sandrock district of the city, 4 ½ miles by ½ mile, the sewer and water pipes are laid in separate tunnels, the sewer tunnels vary in size from 6 feet by 2 feet 6 inches to 7 feet by 7 feet. The channel bricked for water to flow in these tunnels, varies from 9 inches by 14 inches to a horse shoe shaped section 7 feet wide.

The water pipe tunnels are 6 feet high, 3 feet wide—12 inch, 6 inch and 4 inch pipes are laid in the tunnels.

Connections with sewer and water tunnels are made by excavating a drift under the house and drilling down through the rock. The service pipe is then run through the drift and drill hole.

The Telephone tunnel is 3 feet by 6 feet, and has a capacity for over 1000 wires in cables.

Some of the advantages of these underground tunnels for sewers, water pipes, and telephones are, ease of access for examination, repairs and extension of new work: the great relief from tearing up the streets and economy in cost.

Mr. Wilson illustrated his paper by maps, drawings of sections of the work described and photographs showing the work in construction and the completed tunnels for water pipes, telephones and sewers.

F. W. CAPPELEN, Secretary.

THE WISCONSIN POLYTECHNIC SOCIETY.

17TH MEETING, MAY 9, 1892:—There were present, 6 members and 3 guests. President Benzenberg in the chair. Minutes of the sixteenth meeting read and appoved.

The following applications for membership were recorded:

Warren S. Johnson, Electrical Engineer, Geo. W. Goetz, Consulting Engineer.

The applications are to be balloted on by letter before next meeting.

The committee on papers is requested by the President to report on subscription for current technical literature, also to prepare a programme for the summer season until the next meeting.

Paper on "Wheel Records" by Mr. J. N. Barr. In absence of Mr. Barr, the president read the paper to the Society.

Wheel records belong to that class of records, which have for their object greater efficiency and economy in a special department. To establish the useful features of a wheel record, it is necessary to determine upon certain qualities of a wheel, which if united, constitute an "ideal" wheel. The ideal wheel being arrived at, the following departures from the same are noted, with reference to chilled cast iron wheels:

1. Lack of roundness.
2. Variations in thickness of shell of white iron.
3. Imperfections in the white iron.
4. Lack of requisite strength.

To obtain further information on the subject, it is necessary to state the manner in which wheels fail. Wheels fail or are condemned from the following reasons:

1. Failure of the shell of chilled iron.

2. Abrasion.
3. Breaking or fracture.
4. Application of brakes.

The character of service is also of material importance on the mileage of a wheel: therefore the records will have to give information on this point. A distinction is to be made between wheels under freight and passenger locomotives, freight, baggage, passenger and Pullman cars, etc.

Accurate wheel records based on principles as briefly outlined by the paper, manifested their efficiency in a very short time and did a great deal towards the increasing the mileage of wheels.

The discussion following the reading of the paper was taken part in by Messrs. Geo. W. Goetz, Benzenberg, Hathaway, Bentzien, Scholtke. It was very much regretted that the author of the paper was absent, and wishes were expressed to continue the discussion on the interesting subject at a future meeting, in presence of Mr. Barr.

Adjourned 10:15. M. G. SCHINKE, Secretary.

18TH MEETING, JUNE 13TH, 1892:—There were 10 members and one guest present. President Benzenberg in the chair.

Report of the Executive Committee on the letter-ballot for membership of Messrs. Geo. W. Goetz and Warren S. Johnson. Twenty votes cast, all in the affirmative. The two gentlemen are declared members of the society, and the secretary is instructed to notify them to the effect.

As part of the summer programme Mr. Scholtke proposes a visit to the World's Fair grounds as early as possible, so as to see buildings and other structures in the course of erection. The latter part of June or early part of July is proposed. Upon Mr. Goodhue's motion, the arrangements for the trip are placed in the hands of a committee of three. The committee is appointed by the chair and consists of Messrs. Goodhue, Scholtke and Schinke.

A letter from Mr. John W. Weston is read announcing the election of the Wisconsin Polytechnic Society as a member of the Association of Engineering Societies by the Board of Managers. Mr. Poetsch moves that the secretary be instructed to send check for initiation fee and subscription for the JOURNAL to Mr. Weston. Carried.

Election of a member of the Board of Managers of the Association. Nominated Messrs. Hearding, Goodhue, Waterman. Mr. Goodhue receives the majority of votes.

It is moved to appoint a committee of censors for papers to be printed in the JOURNAL by the chair. Motion is carried and the chair appoints Messrs. Hearding, Goodhue and Beck.

Mr. W. K. Means then presented some notes on the history of the bushel measure, based principally upon J. Q. Adams' report to the Senate in 1820. Mr. Means was led to study the subject when asked to measure a large quantity of coal for a gas company. Although our bushel and gallon have no logical relation to each other, they are derived from the same Roman measure, which can be traced back to Greece and Babylon, and are one remove nearer to it than the present British measures. They first appear in English law in 1266 at which time the existing measures were defined and standards were thenceforth kept. Henry VII. made an ignorant attempt to reform the standards of capacity with the result that for two hundred years there were five or six conflicting measures. About 1700 Parliament selected arbitrarily the Winchester bushel and the gal-

lon of 231 cubic inches which continued in use for over a century and have been kept by the United States.

Some of the individual states have varied on this: *e. g.* New York had in 1850 a bushel slightly less than the Imperial, and Massachusetts in 1883 made a special coal bushel intended to equal the heap bushel. The latter quantity is largely left to custom: as far as the U. S. law indicates, it should be 2747 7—10 cubic inches.

The President extends the thanks of the Society to Mr. Means for his interesting remarks.

Adjournment to the second Monday in September, subject to the invitations of the committee on the outing, is moved and carried.

M. G. Schinke, Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

Vol. XI. July, 1892. No. 7.

SETTLEMENT OF THE EMBANKMENT BETWEEN SQUANTUM AND MOON ISLAND, BOSTON MAIN DRAINAGE WORKS.

BY HENRY H. CARTER, MEMBER OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read October 15, 189).]

In order to construct the section of main sewer for the Boston Main Drainage Works between Squantum and Moon Island it was necessary on account of the grade of the sewer in relation to the surface of the ground in the vicinity, to build a high embankment between these points, a distance of about 4200 ft.

The general form of the embankment is shown in cross section, sketches 2, 3 and 4, and the character of the strata on which the embankment is built is shown in the longitudinal section, sketch 1. As will be seen by the sketches, the general form of the embankment was a level roadway about 20 ft. wide at elevation, 32 above Boston City Base. The sides of the embankment then slope down on an inclination of 2 to 1 to the general level of the ground in the vicinity, which was from a few inches to 5 feet above low tide. The slopes of the embankment are protected from the action of the sea by ballast and rip-rap deposited to a height of 5 ft. above high water. From the original surface of the ground up to grade 12 (0 being Boston City Base or about low tide) the embankment is composed of gravel. Above this grade it is of clay and sand, (being the ordinary material found in the excavation of the reservoir at Moon Island) from which the embankment is formed. The particular point of interest attaching to the construction of this embankment (in which a permanent masonry sewer of large di-

mensions was to be built) was to determine the manner in which the soft underlying strata would act under the enormous weight of the filling.

As shown in sketch 1, the orginal surface of the ground on which the embankment was to be located consisted of a gravel bar at about half tide elevation, varying in thickness from 2 to 8 ft., extending from Moon Island about 2800 ft. towards Squantum. At this point the gravel bar disappeared and the surface showed mud alone at about the elevation of low water. The gravel bar as shown on the sketch is underlaid by mud to a depth varying from a few feet to 40 feet; the depth of the mud where there is no gravel bar is from 2 to 18 ft.

Four sets of borings have been taken along the location of this work, three before the completion of the work and the fourth set in 1890.

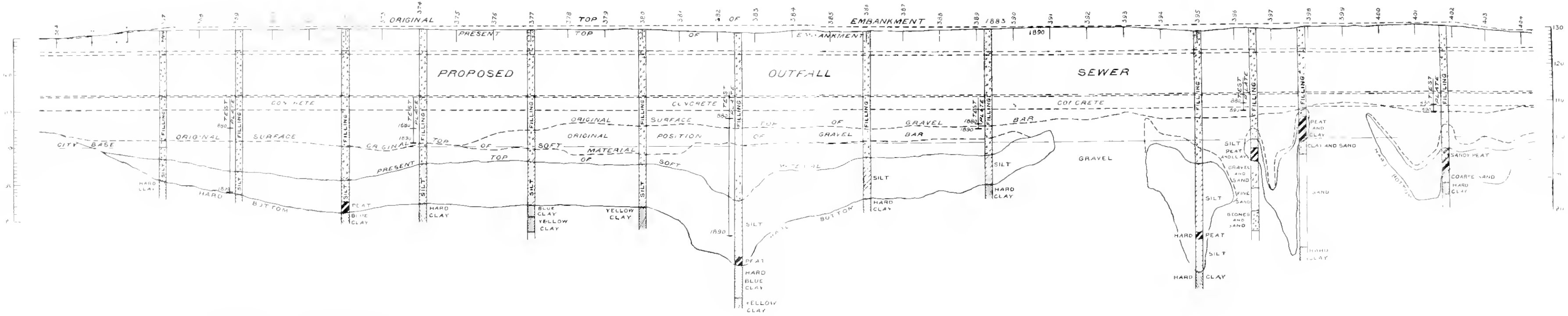
The original set taken in 1876 showed an apparently solid gravel bar extending from Moon Island towards Squantum, mud flats extending from the gravel bar to the Squantum shore; a second set of borings verified the first set. On the indications of these two sets of borings specifications for building the Moon Island reservoir and the sewer in the embankment were prepared and a contract for doing the work was let.

This contract provided for the building of the embankment on the supposed solid gravel bar and for dredging the mud from the rest of the location to hard bottom; then building the embankment from the bottom so obtained.

After the work had been commenced a doubt was raised as to the exact limitation of the gravel bar and further borings were made; it was discovered the entire supposed solid gravel bar was underlaid by mud.

This discovery caused the abandonment of the original intention regarding the building of the sewer. It was decided to give up the idea of building a masonry sewer for some time, also to abandon any idea of dredging out the mud near the Squantum shore, but instead, to pile up the embankment to two feet above the proposed height, and then allow it to slowly settle and come to a permanent bearing before going on with the construction of the sewer.

A very careful set of borings was then made to determine the depth of mud along the whole line of the embankment; the results are shown on sketch 1. In order to observe the motion and settlement of the embankment, 6 rods were placed in position on the filling as it then existed, iron plates 2 feet square were procured and bedded on the embankment and 1-in. pipe rods were screwed into these plates. The idea being, that the plates and rods would settle simultaneously with the embankment and that levels on the rods would show the exact amount



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NOTE THE ORIGINAL POSITION OF SOFT MATERIAL AND HARD BOTT[illegible] WERE DETERMINED BY [illegible] AND [illegible] INTERPOLATED [illegible] BEFORE EMBANK[illegible] WAS MADE

PROFILE SHOWING SETTLEMENT OF EMBANKMENT
ACROSS FLATS BETWEEN
SQUANTUM AND MOON ISLAND
BOSTON HARBOR

SKETCH 1.

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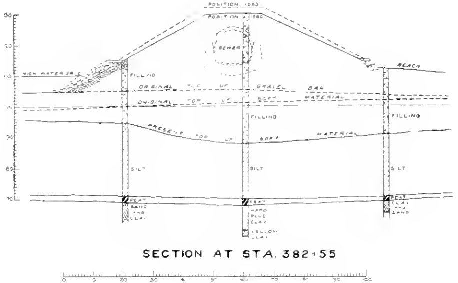
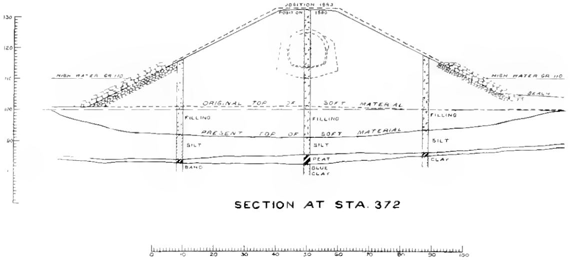


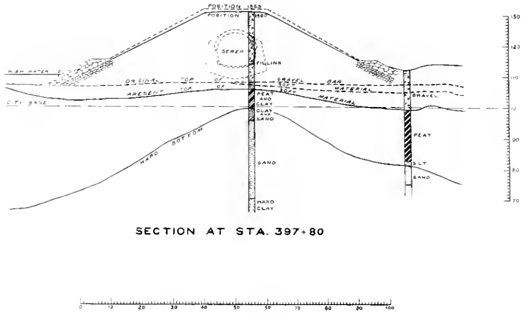
SECTION AT STA. 382+55

SKETCH 2.



SECTION AT STA. 372

SKETCH 3.



SECTION AT STA. 397+80

SKETCH 4.

CROSS SECTIONS SHOWING SETTLEMENT OF EMBANKMENT
ACROSS FLATS BETWEEN
SQUANTUM AND MOON ISLAND
BOSTON HARBOR
1883-1890.

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of the settlement. Additional lengths of rods were screwed on as fast as the settlement took place. The chief interest in regard to the settlement of the embankment is owing to the length of time over which these observations and levels have extended—a period of 9 years.

The first rod was placed at Sta. 369, where the surface was mud which extended to a depth of about 17 feet. The plate on which the rod rests was set at grade 13.5 on the filling which was already in place.

A rapid settlement amounting to 14 feet took place during the first six months of forming the embankment. The embankment, notwithstanding the additional material constantly placed upon it, did not get above grade 16.

An additional settlement of 2 feet took place during the next year, the embankment growing in height to grade 24. In the next year ending December 1883 the additional settlement amounted to .7 of a foot, the embankment having been completed to grade 32 during the year. From December 1883 to October 1890 a further settlement of .56 has taken place. Of this amount .033 occurred during the last year.

The entire settlement up to date is 17.42, which corresponds closely with the depth of mud shown on the plan, thus indicating that the gravel filling has entirely displaced the mud at this point.

A curve of settlement has been plotted showing results from 1885 to date. On this rod it will be seen that the curve is gradually approaching a direction parallel with the axis of the curve.

As settlement of the embankment will continue for some time, and as the construction of the masonry conduit has been commenced, it was necessary to make some allowance for future settlement in determining the grade of the conduit. Theoretical calculations have been made concerning future settlements. These calculations are deduced from the known curve of settlement from 1885 to 1890.

It is found that all the curves of settlement are rectangular hyperbolae of the general equation of

$$a\,y + x\,y - b\,x = O$$

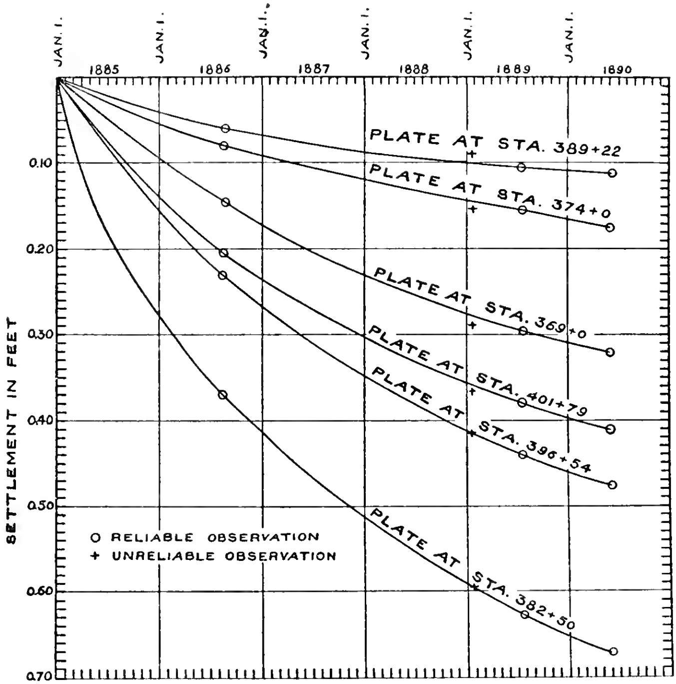
in which a and b are constants, determined from curves as already plotted. x= time in months from January 85, and y = settlement in feet corresponding to the time in months. By using this equation it is possible to determine the maximum settlement which will occur in an infinite time.

It is also possible to determine the year in which the embankment will cease to settle at a rate greater than .01 foot per year.

Applying the equation to the curve of settlement at rod Sta. 369, we get the following interesting results. The maximum settlement which will ever occur is 17.74 feet, and as the rod has already settled 17.41 ft. there remains a further settlement to take place of .32 ft. The rod set-

tled last year .03 ft.; by the middle of 1898 this rate will have decreased to .01 of a foot per year, at which time the total settlement will be 17. 55. It will take to infinity to settle the rest of the distance of .187 feet.

The grade of the conduit has according been elevated about .14 feet above the regular grade to allow for the future settlement. This distance of .14 is the amount of settlement which is calculated to take place between the present time and 1898, or the time at which the rate



NOTE: SETTLEMENT BEFORE 1885 WAS AS FOLLOWS

PLATE AT STA. 369+0	17.095 FT.	PLATE AT STA. 389+22	1.265 FT.
PLATE AT STA. 374+0	3.890 FT.	PLATE AT STA. 396+54	1.535 FT.
PLATE AT STA. 382+50	30.555 FT.	PLATE AT STA. 401+79	1.420 FT.

DIAGRAM SHOWING SETTLEMENT SINCE JAN. I, 1885 OF TEST PLATES IN EMBANKMENT ACROSS THE FLATS BETWEEN SQUANTUM AND MOON ISLAND BOSTON HARBOR

has decreased to .01 of a ft. per year. The uncertainty of the calculations and the fact that the weight of the embankment will be decreased by the removal of 2 feet surcharge, has made it advisable to neglect the settlement which will occur after 1898.

A second rod was put in place at Sta. 374. We can see on sketch 1 that there is about the same amount of mud as at Sta. 369 and should therefore expect about the same results. Instead of this however the total settlement to date has only amounted to about 4 feet instead of 17. Of this settlement of 4 feet, about 2 feet took place the first year the embankment was building; 1 foot settlement took place in the next year, and it has taken from January 1883 to October 1890 in settling the remaining foot.

No reason can be definitely assigned for the way in which this rod has acted compared to the one at 369. Samples of the underlying mud have been procured at both stations by means of sinking $2\frac{1}{2}$ pipes and boring out the core. No apparent difference exists in the samples. It can only be accounted for on the supposition that the filling was put in place in such a way that a gradual and distributed pressure was brought to bear over the surface at Sta. 374, and that at no time was the weight sufficient to cause a sudden movement of the soft material.

Applying our theoretical calculations to the rod at 374, we find the following results:

The maximum settlement which will occur in an infinite time is 4.25 ft. The rod already having settled 4.07 ft. only leaves .18 ft. more settlement. In 1893 the settlement of the rod will have decreased to the rate of .01 ft. per year, at which time the settlement will be 4.10. It will take an infinite time to settle the remaining .15 ft.

The sewer has been placed .04 of a foot above the theoretical grade at this point.

A third rod was put in at station '82 + 50. By looking at sketch 1 we find that a hole of mud 30 ft. in depth underlies the gravel bar, which at this point is 5 ft. in thickness.

From the appearance of the profile, a large settlement should be looked for at this place and the facts bear out the indication—the rod having settled a distance of 31.2 ft. From April 1881 to October 1882 a settlement of a little less than 1 ft. occurred while the embankment was brought up in height from grade 10 to grade 18.

On bringing up the bank to about grade 26 in October of that year, a sudden settlement of 9 ft. occurred which increased rapidly to 28 ft. by December of the same year.

The height of the embankment, while the rod was going down from 9 to 28 ft., varied between grades 17 and 22, material being filled in as fast as settlement occurred. In July,'83 the embankment was brought up to grade 31 and the rod had settled 30 ft.

From July 1883 to October 1890 a further gradual settlement of 1.2 ft. has taken place, .06 ft. having occurred during the last year.

The heavy settlement of the embankment forced up large beds of

mud outside of the bank; these beds are raised up considerably above the surface in the vicinity.

Applying our calculations to the curve of settlement of this rod, we find the following result:

Maximum settlement will be 31.60 feet and as a settlement of 31.23 has already occurred, a further settlement of .37 is expected.

In 1899 the rate of settlement will have decreased to .01 ft. per year at which time the settlement will be 31.42. It will take to infinity to settle the remaining .18 of a foot. The theoretical grade of the brick sewer has been set up at this point .19 in anticipation of this settlement.

Samples of the underlying material procured by borings shows the same characterstics as at 369 and 374 with the exception of a strata of black peat 2 ft. in thickness at grade—30. It should be explained that on sketch 2 the clay and gravel shown from grade 0 to 12 is the result of a recent boring to correspond with the profile on sketch 1. This clay and gravel should be shown as mud which had not been displaced at the time the borings were made.

At Sta. 389 + 22 a fourth rod is located. The mud as shown on the plan is about 16 ft. thick at this point, and from the indications a considerable settlement would be expected.

The entire settlement from 1881 to 1890 is however only 1.37. 1.06 of this settlement had occurred on January 1, 1883 and in the last seven years the settlement has only been .31 ft.

Applying our calculation to this rod we found that the maximum settlement will be 1.44, of which 1.37 has already occurred. In 1889 the rate of settlement will be .01 ft. per year or in other words the rod is now settling less than .01 ft. per year, which is borne out by the curve itself. The conduit has been elevated .06 above grade at this point in anticipation of future settlement.

The material procured from the borings fails to show any reason why the settlement of the embankment at this point should be 1 ft., and at 382 should be over 32 feet.

The fifth rod is located at station 396 + 50 where the gravel bar is underlaid by an extensive body of mud.

The settlement at this point is 2.01 ft. .85 of a ft. occurred during the first two years and the bank has been from 1882 to 1890 in settling the remaining 1.16 foot.

Notwithstanding the small amount of actual settlement which has occurred at this point, the curve showing rate of settlement is one of the steepest and shows that the embankment is still settling at what may be called a rapid rate, it having gone down .05 of a ft. during the last year.

Applying calculations to this curve we find that the maximum

settlement will be 2.42 ft. of which 2.02 ft. has already occurred.

In the year 1900 the rate of settlement will have decreased to .01 at which time the embankment will have settled 2.22 ft. It will take to infinity to settle the remaining .2 ft. The conduit has been placed above grade at this point .21 ft. to allow for the expected settlement.

An inspection of the material as revealed from the borings does not give any satisfactory reason for the small actual settlement at this point. A possible explanation is shown in the thickness of the gravel bar overlying the mud in the vicinity, this thickness being about 20 ft.

The last rod was placed at Sta. 401 + 80. A small pocket of mud is found at this point. The embankment has settled to date 1.83 and 1.03 of this settlement occurred during the first 8 months, so that the settlement from March 1883 to October 1890 has only been .8 ft. The rate however is comparatively rapid as the rod settled .04 during the last year.

Applying our calculation to the rod we find that the maximum settlement which will occur is 2.14, of which amount the rod has already settled 1.83.

In 1898 the rod will have reached the rate of .01 ft. per year settlement.

In this year the total settlement will have reached 1.97 ft. The sewer has been set up above the theoretical grade .14 in anticipation of this settlement.

The settlement of the entire embankment fails to bear out any theory that can be formed. Judging by the profile of borings, there is no reason why a settlement of 17 ft. should occur at Sta. 369 and at Sta. 374, 500 ft. away, where there is the same depth of mud, the settlement should only amount to 4 ft. It was appreciated at the time that the filling took place that the settlement did not amount to what was expected. In order to encourage settlement at stations like 374, where it was evident that the mud was not being displaced, heavy charges of dynamite were put down into the mud by means of hollow tubes. These charges were exploded in the hope that the concussion produced would cause an extensive movement of the filling to take place.

The results of this procedure were however unsatisfactory. A third set of borings has just been completed in order to show the exact characteristics of the material underlying the filling of the embankment. These borings were very carefully made by driving 2½″ tubes and then extracting a core. The material marked on the profile as mud can hardly be called so. It presents the appearance of a very soft plastic clay with muddy discolorations. In some instances this clay is so soft and the black discoloration is so marked that it is difficult to distinguish it from mud, but in general it must be called a clay. Samples

of this material are preserved for inspection by any one who is interested.

The question then becomes how is it that this soft muddy clay in some cases has been entirely displaced by the filling as at 369, and in other places as at 374 it has simply been compressed and still sustains the weight of the filling. It is impossible to satisfactorily answers this question and the only reasonable explanation in my mind is that when the filling was first put in, in some cases the weight was so rapidly accumulated on one spot as to cause a decided movement to take place, which movement did not stop until the filling had entirely displaced the clay. In other cases, the filling may have been spread out and covered so large an area before the weight amounted to much, that a decided movement of the clay did not take place, and that the only change has been a gradual compression of the soft material.

In studying the movement of this embankment in relation to the problem of building a permanent masonry structure in it, we are obliged to assume that the embankment is now in a state of equilibuium or will be in the course of a few years. As shown by the curves the maximum movement which will probably ever take place is less than six inches, and it has been deemed prudent to depend on a future movement of the embankment in accordance with the results of these curves. The question of driving piles for the support of the sewer has been carefully considered. It is thought that great difficulty would be encountered in driving piles through the gravel and clay filling and that the increased expense would not be justified.

If piles are driven, all timber work such as capping and platform would have to be cut off as low as grade 6.5 and a large body of concrete would be required to bring the foundation up to the required grade, thus adding largely to the expense of construction.

The contract for the sewer for about one half of the distance between Squantum and Moon Island has been let. No piles are provided for, but dependence is placed on making a heavy foundation act as a beam to bear the stresses caused by the expected small settlements in the bank. It is intended to insert iron rods in the arch at stations where the original rods were located, in order that additional settlement may be kept track of, and it may be seen how far the theory of settlement is borne out by the actual settlements.

LAKE CURRENTS.

By W. H. Hearding, Member Wisconsin Polytechnic Society.

[Read April 11, 1892.]

In the discussion which followed the reading of the paper upon the Physical Characteristics and Harbor Improvements of Lake Michigan, at your regular meeting in December, mention was made of a current having been frequently observed at a short distance from the shore, which carried the water from the pumping station on Jones' Island, as far to the southward as the south point of Milwaukee Bay. I have no doubt as to the accuracy of this statement. Since the date of that meeting, I have seen it stated in one of the daily papers of this city, without qualification, that "the current comes from the north", which statement also (under certain conditions) is undoubtedly correct. If it had also been said by an eye witness, that the discolored water discharged either from the pumping station, on Jones' Island, or from the river, had been seen approaching the vicinity of the North point of the Bay, I should also have said the statement was probably true. In the *Evening Wisconsin* of February 22nd. last, an item read as follows: "The river presented an unusual appearance this morning. Its surface was covered with snowcapped cakes of ice which had been driven into the harbor by an easterly wind, and then carried up stream by an insetting tide. The ice was taken up the main river as far as Michigan Street and Grand Avenue Bridges". All of these statements are without question truthful, notwithstanding their being apparent contradictions. Before proceeding directly with our subject, may I ask your attention to a rough sketch of the Lake region which shows one of the governing physical conditions of its environment. The area of the water-shed of the lakes is tinted in Orange. The lake area is shaded in Blue. The area of the water-shed is not so extensive as is generally supposed. The line which divides the water-shed of this section from the sections which surround it, does not exceed 130 miles at its farthest point from lake water. At some points, it is narrowed to a width of less than 10 miles. The surface area of the four upper great lakes is 88,020 square miles. Their water-shed is 152,900 square miles, which is not twice the area of lake or water surface. To the northward of the lake basin, the affluents of the Hudson's Bay carry away the water supply. The Upper Mississippi and the Red River of the North, drain a large section of country on the North and West, the Ohio on the south, and the Ottawa on the north and north-east, so that the lakes are not the recipients of the precipitation of a very large section of country as is above shown. It will be seen that Canada and the State of Michigan furnish a large percentage of the water

supply. The question as to the existence of lake currents is one which has for many years attracted much attention. The importance of this subject has increased with the growth of the cities and towns which have been established upon the shores of the lakes. Persons of reputed authority on kindred subjects have expressed the opinion, that a constant current, with a defined course is known to exist in the waters of Lake Michigan, and these expressions have probably given rise to the general idea that such a current actually does exist. One cause of the increasing interest which is attached to the current question is due to the fact of the lake being the source from which the principal cities on its borders derive their chief supply of water for general domestic use, and also, by reason of the lake having been made the recipient of the sewage of those cities in which a system of sewerage has been introduced. Chicago, Milwaukee, Racine and otner cities on the shores of Lake Michigan, have adopted the method of discharging the product of the sewers into the lake, for the reason that it is more readily and cheaply disposed of by such method, than by any other, and it is due to this seemingly unavoidable practice, that the subject is of such importance. If a constant littoral current, invariable in its course were absolutely known to exist, one of the perplexities attending the work of an engineer would be much lessened in the establishment of a water supply for a city, as also in the selection of a proper point for the delivery of sewage into the lake; for with a known constant current, it would be possible to place a conduit for the intaking of water in such a position as would almost, if not absolutely preclude the possibility of its being contaminated by the refuse disposed of as above stated. But when the directions of currents are subject to change, the water taken from the lake, may under certain conditions be in danger of pollution, through the incautiously placing of an intake pipe in too close proximity to the point where sewage is discharged.

In order to acquire a more precise knowledge of lake currents than has yet been ascertained, it would be interesting to formulate some method whereby their action could be more approximately determined, by means of floats or meters, observations upon which, for direction and velocity, should be taken for such a length of time as might be necessary to establish facts in regard to the conditions which govern them. The barometer might also be useful as an indicator in this connection. Various articles have recently been published in the daily journals in relation to a method for determining the action of lake currents, by means of tightly sealed bottles which are to be set adrift from vessels in different sections of the lakes, each bottle to contain a written statement of the date, time, and locality of the point at which it is immersed. When it is picked up by parties on some

other passing vessel, or on shore, the date, time and place of its recovery is to be noted, and forwarded to the promotors of the system. Such an attempt to elicit information is praiseworthy, and deserving of success, even if a full measure of success is not attained thereby. (Since the above was written, I learn that this system is to be under direction of the weather bureau.) To one whose pursuits have led to a partial consideration of the general character of the streams which enter Lake Michigan, and who has been somewhat observant of the effects of atmospheric influence upon this body of water, the idea of the existence of a constant current seems to be very questionable. An examination of the topography of the surrounding country shows that the number of streams of sufficient magnitude to justify particular consideration, and which contribute a constant flow of water into this lake is limited.

The Fox, Menomonee, and Oconto rivers, which discharge into Green Bay: the Kalamazoo, Grand, St. Joseph, Manistee and Muskegan rivers, which enter the lake from its eastern shore, and the Manistique from its northern shore, are the principal streams. Of these, the Fox, Menomonee, Manistique and Grand Rivers, are the largest tributaries, and furnish a constant supply of greater or lesser magnitude at all seasons of the year. The other streams mentioned, may be considered as periodic in outflow, as the volume of water contributed by them is small, excepting their discharge during freshets. Many of the streams may be classed practically as dead rivers during six months of the year. The freshet periods are of but short duration, and the directions of the discharges of the several streams are in many instances directly opposed to each other, being situated on the opposite shores of the lake. Even during the periods of freshet, the volume of discharge of the streams is small as compared with the body of water in the lake, and these comparatively small outpourings from opposite shores, are but as minute threads in the expanse of such a body of water as is contained in Lake Michigan, and have but little effect in the formation of lake currents. The outflow of the largest of the streams is quickly lost in the main body, and the molecules which formed a strong current when confined within narrow bounds, are soon reduced to comparative inactivity through the resistance offered by the body of water into which they merge. In addition the smaller streams which assist in carrying the water which is shed from the elevated ground adjacent to their borders, it is reasonable to suppose that there are as many springs issuing from the bed of the lake, as from an equal area of land which is above its surface, and which contribute to the maintenance of its general head. Changes in the height of the lake surface are of almost daily occurrence. Some of these are not unfrequently quite marked. A difference of as much

as two, or even three feet in surface level, has been observed in some localities, within the space of a few hours; but such excessive changes are exceptional. A rise or fall of six inches within the space of an hour is not unfrequent. It is therefore apparent, that in the case of a rise, a current must have been set temporarily in the direction of the section of the lake where the rise has taken place, and in the case of a fall, its trend must have been in an opposite direction. A current has been frequently noticed, setting through the Straits of Mackinac, from Lake Michigan into Lake Huron, and at other times its flow has been observed running in the opposite direction. These changes in direction are satisfactory evidence as to the general level of the water surface in these two lakes being practically the same, although the natural head of water in Lake Michigan, when undisturbed by extraneous forces is conceded to be situated at its southern extremity. This nominal head may however be generally considered as theoretical, for the reason that the effect of the aggregated volume of the small streams which enter that section of the lake, is more than counterbalanced by a slight increase in the pressure of a heavy atmosphere upon the surface of the water. The pressure of a denser atmosphere at the south end of the lake, will force the water in a northerly direction, and thus temporarily transfer the head farther northwards. When this pressure is removed from the southern section, the water will again rise, or in other terms, flow towards and into the southern section. Similar fluctuations are not unfrequently due to the force of wind storms, which drive forward the surface of the water which is in front of them. I have heard it suggested that some of the fluctuations may be due to seismic action, but if this were the case, any such kind of force, capable of producing such effect, would also be sensibly felt upon the shores of the lake. It is evident that a constant current must proceed from a constant head, and if the high water level or head is subject to change in locality, it is improbable that a constant current can exist.

A remarkable illustration of the action of lake currents was observed by the writer some forty years ago, on the south shore of Drummond Island in Lake Huron. This island is situated on the east side of the mouth of the St. Mary's River. A deep bay penetrates the southwest section of the island, and upon the west side of this bay, Fort Drummond was formerly situated. On the east shore of the bay, is a small cape of land, in the interior of which is a pond of about eighty acres in extent. At the time mentioned, the timbers of an old flume, were still in place, which connected the water of the pond with the water in Lake Huron. The set of the current through the flume was very strong, first inwards for a period of from ten to fifteen minutes, then for a similar period it flowed as rapidly in the opposite di-

rection. It is probable that the oscillatory movement of the current was due to changes in atmospheric pressure, the movement being quite active during a prolonged term of calm weather. The flume was about eight (8) feet wide, and when the current was at full ebb, it required the force of several men to push a large row-boat against it into the pond. Littoral currents which are due to the translation of water impelled upon the shores of a lake, by the breaking of waves, are active in proportion to the length of the reach of deep water across which the waves have passed, and to the force and duration of the storms which have generated them, and while in operation, they often effect marked changes in a line of shore which is comprised of moveable material; the greatest effect being produced by a sea running in an angular direction to the trend of the shore upon which the wave force is broken. These littoral currents fluctuate with the changes in direction of the wind.

The water level in the northern section of Lake Huron is subject to changes similar to those in Lake Michigan, but for some short distance above its outlet through the St. Clair river or straits, which carries the whole of the unevaporated volume of the water shed of lakes Superior, Michigan and Huron, a current which is constant in direction, follows the Michigan shore. The quantity of water discharged through the straits of St. Clair, as officially determined is 225,000 cubic feet per second. This gives as a result in one year a total outflow of 7,100,460,000,000 cubic feet. The combined area of the three lakes is 77,450 square miles. The average depth of water in these lakes is taken at 400 feet, or one thirteenth part of a mile. The total volume water contained in these lakes is about 5,958 cubic miles or 877,005, 398,016,000 cubic feet, and if the water supply from all sources should be cut off, and the discharge of 225,000 cubic feet per second were uninterruptedly continued (eliminating the factor of evaporation) it would take about 123 years time, to draw off the whole of the water which is stored in these basins, through a conduit whose discharge should be equal to that of the St. Clair river, and this one hundred and twenty third part is all which is derived annually from all sources of supply, and when it is further considered, that this quantity is the resultant of outflow for 365 days, the insignificance of the discharges of ths streams which are scattered along nearly four thousand miles of shore line, and their effect towards producing constant currents in the lakes is apparent. The mean annual precipitation during a period of twenty-eight years, upon the Lake Superior basin, has been determined at 2.58 feet, and the area of the water-shed including the lake area is 82,800 square miles. The mean annual precipitation during the same period, upon the united areas of the lakes and basins of Lakes Michigan and Huron is taken at 2.86 feet, their united areas being 115,

650 square miles. The total rain fall over the combined basins of the three lakes in one year is 15,176,527,037,200 cubic feet, which is more than twice the volume of discharge of the St. Clair river. It is evident therefore that the loss by evaporation (which includes the land soakage) is more than one-half (probably three-fifths) of the water which is contributed from all sources.

Another illustration will show that the total volume of water discharged from the three great lakes, in comparison with the movements effected by atmospheric pressure is small. A rise of six inches over an area equal to one quarter of the area of Lake Michigan is greater in volume than one-sixth of the mean annual precipitation over the same area, and it also represents a displacement equal to one-ninetieth $^1/_{90}$ part of the total discharge through the St. Clair River in one year, or the quantity which is discharged in the space of about four days, and more than twelve times as much as is precipitated into the whole of Lake Michigan in that space of time. Such a movement is sometimes effected in the space of a few hours. To demonstrate this, we find that one square mile contains 27,878,400 square feet. The number of square miles in $\frac{1}{4}$ area of Lake Michigan is 5,610. Then for a rise of six inches as above stated we have

$$27{,}878{,}400 \times 5{,}610 = \frac{156{,}397{,}824{,}000}{2} = 78{,}198{,}912{,}000$$

cubic feet of water displaced, and the discharge through the Straits of St. Clair in 4 days is 77,760,000,000. The quantities which have been introduced to verify what has been stated, seem to be very large but they are only relatively so, for if we should be disposed to make farther comparisons, we should find that to form one Gulf stream it would require the volume of more than 5,000 such rivers as that of the St. Clair. Without farther digression it is reasonable to suppose that the lake currents are subject to changes in direction in accordance with the varying pressures imposed by the atmosphere upon the water surface.

An occurence similar to that above cited for illustration, happened while I was engaged in surveying the east arm of Grand Traverse Bay, Michigan. Buoys had been placed out preparatory to taking soundings, some of which were set in water from 60 to 80 fathoms deep. On the following morning, one of the assistants attached to my party left camp for the purpose of commencing the work of sounding between the buoys and shores, but could find no buoys. His first thought was, that some one in need of rope must have taken them up and stolen the lines, and so reported. I advised him not to be too hasty in his condemnation of the honest Indians and settlers living in the vicinity, but to await further developments. Upon going out the next day, every buoy was found to be in its proper position. The tempo-

rary disappearance of the buoys was due to a strong current which was running out of the bay, and which had drawn them down below the surface of the water, and kept them hidden there until the equilibrium of the two elements was restored, when they again assumed their former vertical positions.

On the 19th of January last, I noticed an item in the *Evening Wisconsin,* which stated that in the Northwest the barometer had been ranging very high, but on that day it had fallen over an inch. I clipped this from the paper, and the next day's issue described a phenomenon very similar to the occurrence mentioned above, only that it is said to have occurred in the west, instead of the east arm of the same bay and was much more marked in its effects. The article was written at Traverse city and read as follows: "At a few minutes before 8 o' clock the wells at the water-works and the electric light plants gave out simultaneously. The men at the plants began investigating, compared notes, and concluded that the intake pipes from the bay had been blocked by floating ice. They went to the bay to investigate and found the bottom of the bay entirely bare for fully 100 feet from the usual shore-line. The water had failen fully seven feet. Boats of all kinds, steam and sail were grounded. Docks were high and dry upon the beach, and pleasure cottages that but an hour before had their steps lapped by the waters of the bay, were now seven or eight rods from the water line. For fully an hour, the city was in total darkness, and many assembled at the beach and upon the docks to view the curious phenomenon. Then with a mighty rush, the waters came back to their natural place with the force of a tidal wave. The waves tumbled over each other as though lashed by a mighty wind, and their tops threw clouds of spray many feet into the air. Boats were washed from their moorings and cast many feet upon the beach; dock piles were loosened and came tumbling into shore with the rushing waters, and the doors and windows of many of the cottages were smashed in. The damage was considerable, especially to shipping. Once before this fall, the water in the bay fell five and one-half feet in two days, but last night's sudden fall discounts any record kept by the oldest inhabitants. As no strong breeze was blowing from off shore, the mystery seems the more inexplicable." A question may possibly be suggested in regard to the probability of the existence of constant lake currents, which are proportionate in volume and similar in action to those of the ocean. A reply to this would be, that the general conditions or agencies which produce ocean currents are wanting in the comparatively circumscribed area of the lake region, the whole of which is inclosed within the boundaries of eight degrees of latitude, in a temperate zone, and is practically unaffected by tidal influence, whereas the ocean, extending from the torrid to the frigid

zones is subject to extremes of heat and cold, and the difference in the temperature of the water, is generally conceded to be one of the chief causes of constant upper currents. The influence of the lunar tide in the formation of currents in any of the lakes is very slight. Some years ago, observations were made with a view to determine its amplitude in Lake Michigan, which are said to have determined its height at 1 ½ inches, but the changes which are due to atmospheric influence would seem to be of such superior magnitude as to render an exact determination of the effect of lunar attraction almost impracticable. That a tidal action due to lunar influence takes place as regularly in Lake Michigan as in any other body of water is undoubtedly true, as it also occurs in even a pail of water, or a bowl of punch, but the liability to disturbances or interferences incident to the latter case cited, would render the obtaining of its exact amplitude somewhat difficult. Instances are not unfrequent when a current is found to be running in an opposite direction to that of the wind, with a force sufficient to prevent a vessel from being kept closely moored to one of the open pile piers, which until recently were used as landing places for steamers engaged in the coasting trade of the lakes. Any experienced commander of one of these steamers could without doubt cite many instances when he had been obliged to cast off the lines, and move to the current-ward side of the wharf, by reason of this opposition of forces.

It has been shown that the volume of water discharged by the streams which enter Lake Michigan is small in comparison with the expanse into which they are merged. In discussing the variations in the heights of water surface due to atmospheric pressure reasonable proof has been given of the variableneness of the currents thereby engendered; and it is apparent that the lunar tidal influence is inappreciable. It would therefore seem as though the wind force and the configuration of the lake shores and bed, are the only remaining sources which can possibly effect the maintenance of a constant current. The variableness of the wind over the lake region, and the absence of what are termed trade winds on the ocean, must be accepted as sufficient argument against this theory. Peculiarities in the form of a shore, such as a deep bay, similar to that of Grand Traverse; or a reef or shoal, may sometimes conduce to the formation of a temporary local current, but in the absence of perceptible lunar tides, they offer no proof of the constancy of currents in bodies of water which are subject to sudden fluctuations through changes in atmospheric pressure. The insignificance of the volume of water discharged by any one of the streams entering Lake Michigan, as compared with the whole volume which is contained in the lake has been shown by way of illustration. If, however, any one of these streams, having a discharge of

three or four thousand, or more cubic feet per second, should be diverted from its course to the lake, in some other direction, its effect would not be immediately perceptible, but such a diversion would without doubt ultimately affect the mean lake level, proportionately with the quantity of water thus diverted. If this were not the case, it might be proper to advance the theory, that no perceptible change would be made in the general level of the lakes, if the water of a the streams which enter them were shut out. The dependence of the head of water upon the rain fall, has been well exemplified recently. A comparison of the records of the Meteorological Office, with those kept in the U. S. Engineer Office, shows the deficiency in amount of precipitation from January 1886 to January 1892, to have been about 20 inches, and the lake surface on January 1st. of this year, was 24 inches below its mean level. ***A lack of precipitation is in its effects, the same as would be produced by any other kind or method of diversion or abstraction.***

MAXIMUM STRESSES IN DRAW BRIDGES.

BY PROF. MALVERD A. HOWE, MEMBER ENGINEERS' CLUB OF ST. LOUIS.

[Read May 18, 1892.]

Within the limits of this paper it will be possible to consider only the stresses in the main trusses of draw bridges consisting of *two equal spans.*

The live and dead loads will be assumed as concentrated at the panel points. For equal panels, the live load concentrations will be considered as equal.

The "Three Moment Theorem" will form the foundation for the few formulas introduced.

The following cases will be considered.

A.—Stresses due to the dead load alone.

a. When the draw is open.

b. When the draw is closed, both ends just touching the supports and latched or unlatched.

c. When the draw is closed and both ends are raised, causing definite reactions at the end supports.

d. When case *c* is supposed to obtain and through carelessness or an accident only one end is raised.

B.—Stresses due to the live load alone.

a. When draw is closed and ends just touch the supports when no live load is on the bridge, both ends latched down.

b. Same as case *a*, but the end towards which the live load is moving *not latched down.*

c. Same as case *a*, but end which live load is leaving not *latched down.*

d. When draw is closed and ends are raised causing definite dead load reactions.

e. Same as case *d*, but end towards which live load is moving, *not raised from the support.*

f. Same as case *d*, but end which live load is leaving *not raised from support.*

A.—Cases *a, b and c*, need no discussson here as the methods of determining the stresses are well known.

In case *d*, since the end reactions are zero before the ends are raised, the end reactions will be equal whether one or both are raised and the stresses can be found by the usual graphical methods.

B.—Case *a*. Since the draw touches all the supports and cannot leave them owing to the ends being latched down, the bridge is a continuous girder of two spans. (A method for quickly determining the loads which produce like stresses in the truss members will be given later.)

Case *b*. Since the dead load is balanced on the turntable support, as the live load enters the arm which is latched down the unlatched arm will leave its end support, hence, as long as the live load does not enter the unlatched arm, the latched arm is to be considered as a discontinuous span in determining the stresses. As the live load passes over the turntable support into the unlatched span, the latched arm can no longer be considered as discontinuous and the unlatched arm will act as a cantilever until sufficient load has been added to the unlatched arm to cause a reaction at its end support when the bridge immediately becomes a continuous girder of two spans.

This case can, of course, obtain only under gross carelessness or by the failure of the locking machinery, and hence is not usually found in specifications.

Case *c*. As the live load enters on the unlatched arm it will immediately bear upon its support and the bridge becomes a continuous girder of two spans. As the live load leaves the unlatched arm this becomes case *b*. For the reasons stated under case *b*, this case is not included in specifications.

Case *d*. The bridge is a continuous girder of two spans.

Cases *e* and *f*. If the ends are designed to be raised the proper amount the bridge will be a continuous girder of two spans. As these two cases cannot obtain unless under gross carelessness or the breaking of the raising machinery, they are not as a rule included in specifications.

Then the following assumptions may be considered as sufficient in computing the stresses in a draw bridge of two spans.

I.

The ends of the draw latched down when closed.

α. Draw open and subjected to dead load only.

β. Draw closed, ends latched down, and entire dead load carried by turntable support.

γ. Draw closed, ends latched down, and considered as a continuous girder of two spans for the live load alone.

Cases α, or cases β and γ combined, will give the maximum stresses.

II.

The ends of the draw raised when closed.

α. Draw open and subjected to dead load alone.

β. Draw closed, ends raised, and subjected to dead load alone.

γ. Draw closed, ends raised and considered as a continuous girder of two spans for live load alone.

Case α, or cases β and γ combined, will give the maximum stresses.

As the methods of determining the stresses due to the dead load are well known it will not be necessary to consider them here. There remains then to consider the method of determining the stresses due to the live load when the bridge is considered as a continuous girder of two spans.

From the "Theorem of Three Moments" the following equations are easily deduced.

Let M_2 = the bending moment over the turntable support.

S_1 = the reaction at the left support of the first arm.

P_1 = any concentration in the first arm.

P_2 = any concentration in the second arm.

a_1 = the abscissa of any load P_1. (The left support being the origin.)

a_2 = the abscissa of any load P_2.
(origin at left support of second arm.)

L = the length of either arm.

$$k_1 = \frac{a_1}{L}$$

$$k_2 = \frac{a_2}{L}$$

$$K^1 = k - k^3$$

$$K = 2k - 3k^2 + k^3$$

X_0 = The abscissa of the point of zero moment in the first arm for any load P_1 or P_2.

For loads in the first arm

$$M_2 = -\frac{K_1^1}{4} P_1 L \qquad (1)$$

For loads in the second arm

$$M_2 = -\frac{K_2}{4} P_2 L \qquad (2)$$

where $K_1^1 = k_1 - k_1^3$ and $K_2 = 2k_2 - 3k_2^2 + k_2^3$.

For loads in the first arm

$$S_1 = \left((1 - k_1) - \frac{K_1^1}{4} \right) P_1 \text{ (always positive)} \qquad (3)$$

For loads in the second arm

$$S_1 = -\frac{K_2}{4} P_2 \text{ (always negative)} \qquad (4)$$

For loads in the first span

$$X_0 = \frac{a_1}{1 - \left((1 - k_1) - \frac{K_1^1}{4} \right)} \qquad (5)$$

For loads in the second span

$$X_0 = 0 \qquad (6)$$

From equations (2) and (6) it is seen that all loads in the second arm cause negative moments in the first arm.

From Diagram I the values of X_0 for loads in the first arm can be found and those loads selected which cause negative moments at any specified point; these loads with those in the second arm will cause the maximum negative moments at this point; all other loads will cause positive moments at this point.

Knowing the proper loading the maximum chord stresses are easily obtained graphically by taking S_1 from Diagram I and using Clerk Maxwell's graphical method or by taking the values of M_2 from the Diagram and drawing the equilibrium polygon.

From equation (3) it appears that the shear in the first arm is positive for all loads in that arm and from equation (4) that the shear is negative in the first arm for all loads in the second arm.

Then to obtain the maximum stresses due to negative shear, consider the second arm as loaded over all and the moving load in the first arm as moving from the end towards the turntable.

Take the values of S_1 from the Diagram I and compute the shear by considering the first arm as *discontinuous* using the values of S_1 as reactions. The extent of the load in the first arm will follow the same law as for discontinuous bridges.

For the maximum stresses due to positive shear consider the second arm as empty and the moving load in the first arm as moving from the turntable towards the end of the arm; treating the span as discontinuous and using the values of S_1 as given by Diagram I as reactions.

The extent of the load follows the same law as for discontinuous spans.

To illustrate the utility of Diagram I and the simplicity of the method outlined above, the following example is solved:

From Fig. 1. the following values are obtained for load at panel point.

No.	a_1	k_1	a_2	k_2
1	19	0.106	28	0.894
2	38	0.211	47	0.789
3	57	0.317	66	0.683
4	76	0.422	85	0.578
5	95	0.528	104	0.472
6	114	0.633	123	0.367
7	133	0.739	142	0.261
8	152	0.844	161	0.156

From Diagram I. the following values of X_0 are obtained for loads in first arm at panel point.

No.	a_1	$X_0 = F \times L$
1	19	$0.802 \times 180 = 144.4$
2	38	$0.807 \times 180 = 145.3$
3	57	$0.818 \times 180 = 147.2$
4	76	$0.829 \times 180 = 149.2$
5	95	$0.846 \times 180 = 152.3$
6	114	$0.870 \times 180 = 156.6$
7	133	$0.898 \times 180 = 161.6$
8	152	$0.934 \times 180 = 168.1$

Comparing the values of X_0 with the values of a_1 which are the abscissas of the center of moments for the chords as well as the positions of the loads P_1, the following conclusions are readily reached:

1. The maximum positive moments for all centers of moments

from 1 to 7 inclusive will obtain when panel points 1 to 8 inclusive of the first arm are loaded.

2. The maximum positive moments for the center of moments at 8 will obtain when panel points 5 to 8 inclusive of the first arm are loaded.

3. The maximum negative moments for all centers of moments from 1 to 7 inclusive will obtain when all panel points in the second arm are loaded.

4. The maximum negative moment for the center of moments at 8 will obtain when all panel points in the second arm and panel points 1 to 4 inclusive of the first arm are loaded.

5. From equations (1) and (2) it is evident that for center of moments over the turntable support, all moments will be negative and a maximum when both arms are loaded at each panel point. The magnitudes of the maximum moments are easily and quickly obtained as follows:

First determine the values of M_2 from Diagram I.

For loads in the first arm at panel points.

No.	$M_2 = F\ P \times L \div 10$	
1	$-\ 0.0605\ P_1 \times 18 = -\ 10.890\ P_1$	$= 60.138\ P_1$
2	$-\ 0.0837\ P_1 \times 18 = -\ 15.066\ P_1$	
3	$-\ 0.0947\ P_1 \times 18 = -\ 17.046\ P_1$	
4	$-\ 0.0952\ P_1 \times 18 = -\ 17.136\ P_1$	
5	$-\ 0.0865\ P_1 \times 18 = -\ 15.570\ P_1$	$= 42.264\ P_1$
6	$-\ 0.0714\ P_1 \times 18 = -\ 12.852\ P_1$	
7	$-\ 0.0506\ P_1 \times 18 = -\ 9.108\ P_1$	
8	$-\ 0.0263\ P_1 \times 18 = -\ 4.734\ P_1$	
	$-\ 102.402\ P_1$	

Since the draw is symmetrical, the value of M_2 for loads in the second arm will be the same as the above reading from the bottom upward.

For positive moments 1 to 7 inclusive, loads 1 to 8 inclusive in first arm are to be used. Lay off the load line A, B, - - - I in Fig 2. Assume any pole and construct the equilibrium polygon M, S_1, S_2 - - - N

connecting the points M and N by a right line. From N lay off $N\ O = \frac{M_2}{H} = \frac{102.4}{H} P_1$ and draw $M\ O$.

Then the ordinates between $M\ O$ and the equilibrium polygon under the panel points 1, 2- - - 7 inclusive muliplied by H will be the maximum moments at these points.

For the maximum positive moment at panel point 8, only loads 5 - - 8 inclusive of the first arm are to be used.

Following the same method as outlined above in Fig. 3, the ordinate under 8 multiplied by H will be the maximum positive moment at 8.

For the maximum negative moments from 1 to 7 inclusive only the loads in the second span are to be employed.

In Fig. 2, the ordinates between the lines $M\ N$ and $M\ O$, multiplied by H, under points 1 to 7 inclusive give the maximum negative moments at these points respectively.

For maximum negative moments at 8 the second arm is to be loaded over all and loads 1 to 4 inclusive in the first arm are to be considered also. From Fig. 1, the negative moment due to the loads in the second arm is given by multiplying the ordinate between the lines $M\ N$ and $M\ O$ by H and the similar ordinate in Fig. 4 between the line $M\ O$ and the string S_4 multiplied by H gives the negative moment due to the loads 1 to 4 inclusive; the sum of these two moments gives the maximum negative moment at 8.

The maximum negative moment over the turntable equals 102.4 $P_1 \times 2$ equals 204.8 P_1. Thus the maximum positive and negative moments are quickly obtained by drawing *three* equilibrium polygons.

The determination of the web stresses needs no explanation further than the statement that all loads in the second arm cause negative shear in the first arm which must be increased by the negative shear caused by the moving load in the first arm moving from the end towards the turntable.

The maximum positive shear is caused by loads in the first arm only and moving from the turntable towards the end of the arm.

The values of S_1 for loads at panels points given below can be found from Diagram I.

The determination of maximum stresses by the above method is very simple and at the same time exact.

In case the panel concentrations are not equal, the determination of the maximum stresses is somewhat more tedious; although the field of loads giving moments or shears of the same kind do not change, yet the distribution of the various concentrations within these fields affects the magnitudes of the moments or shears.

Probably the simplest method of procedure is to tabulate the mo-

No.	$S = F$, First arm.	$S = F$, Second arm.
1	$+ 0.867 P_1$	$- 0.0605 P_2$
2	$+ 0.738 P_1$	$- 0.0837 P_2$
3	$+ 0.612 P_1$	$- 0.0947 P_2$
4	$+ 0.492 P_1$	$- 0.0952 P_2$
5	$+ 0.375 P_1$	$- 0.0865 P_2$
6	$+ 0.273 P_1$	$- 0.0714 P_2$
7	$+ 0.177 P_1$	$- 0.0506 P_2$
8	$+ 0.095 P_1$	$- 0.0263 P_2$

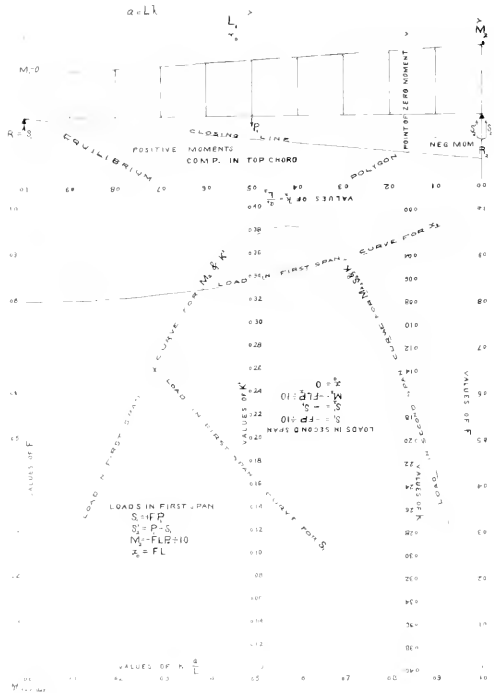
ments and shears for each panel for each load and then distribute the concentration as nearly as possible according to the magnitudes of the moments and shears thus tabulated.

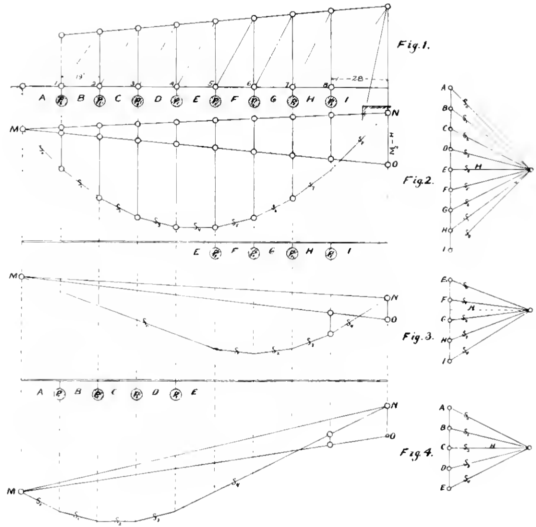
This tabulation is very quickly made after the equilibrium polygons have been constructed.

In case a uniform load and an engine excess is specified, the method explained above can be employed for the uniform portion of the load and then the stresses due to the excess alone can be determined by the method of tabulation.

If wheel concentrations are specified the determination of maximum stresses becomes very complex. Either an *assumed* uniform load or a uniform load with an engine excess will give stresses close enough for all practical purposes.

All draw bridges having a short span over the turntable can be considered as two span girders only, when there is no web bracing in this span or such web bracing is so arranged that it cannot possibly act when any live load is on the bridge.





MAXIMUM STRESSES IN DRAW-BRIDGES OF TWO EQUAL SPANS.

ASTRONOMICAL SPECTROSCOPY, WITH SPECIAL REFERENCE TO THE MOST RECENT PHOTOGRAPHIC DEVELOPMENTS.

By Dayton C. Miller, D. Sc., Member, Civil Engineers' Club of Cleveland.

[Read April 12, 1892.]

Recently one of the most generous benefactors of Princeton College gave to the Halsted Observatory a new spectroscope which, in several respects, is more powerful and complete than any before in use. Prof. Young, the director of the observatory, was among the first to apply the spectroscope to the study of the physical and chemical constitution of the sun, and his work and discoveries have made him one of the highest authorities on the subject. For this line of work the two Princeton observatories are specially well equipped with two telescopes of 9½ inches and 23 inches aperture, fitted with no less than six spectroscopes of all sizes. It has been the writer's privilege to spend the greater part of three years at these observatories and to assist, in the summer of 1891, in setting up and adjusting the new spectroscope and in some preliminary work done with it. The object of this paper is to describe this instrument and the work that has been done with it, together with brief mention of work of a similar nature, being carried on at two other observatories.

In the original paper the sun was considered as the typical source of energy and the fundamental optical theory of the spectroscope was explained as briefly and simply as possible, and the principles of spectrum analysis given. The construction of the spectroscope in its different forms was described.

The principal astronomical facts relating to the sun, and especially the structure of the solar photosphere and spots, chromosphere and prominences, and corona, were explained. The application of the spectroscope to the study of the physical and chemical structure of the sun was outlined.

The new spectroscope for the 23 inch telescope of the Princeton observatory was made by Brashear, of Allegheny, who also made the spectroscope for the Lick Observatory. It is a universal instrument as regards its adaptability to all kinds of spectroscopic work, and, in completeness of detail and in its efficiency, it is not equalled by any other instrument yet constructed.

The collimator and view-telescopes are each provided with two sets of objectives of 2½ inches diameter and 30 inches focal length; one set for visual observation, the other set specially corrected for photographic work. According to Prof. Young's idea the objectives of both collimator and view-telescope are focussed together by one motion.

The slit-plate with its attachments is one of the most elaborate and

carefully constructed parts of the instrument. The slit is adjustable in width from zero to one-half inch, and in length from zero to one inch. It can be moved laterally on the slit-plate. It is fitted with a comparison prism, and an attachment for producing the electric arc for forming metallic spectra used in comparisons. It has a rotation prism for making any portion of the sun's limb tangent to the slit without turning the eye-piece out of a convenient position. Above the slit is a set of colored screens, and just below it is arranged a small telescope for observing the slit in order to place it exactly upon a star-image.

The spectroscope is attached to the large telescope by four steel tubes held in a light frame-work in such a manner that the whole can be rotated around the optical axis. The collimator is held inside this frame-work and is adjustable laterally so that its axis can be made to coincide with the optical axis of the large telescope; and it is moveable along the optical axis several inches, to bring the slit into the focus of the large objective for that portion of the spectrum under study.

The view-telescope is held in place by steel arms attached to the main frame-work so that its axis can be adjusted as required. It is fitted with a micrometer having electric illumination for the wires. The view-telescope can be separated at its middle, the micrometer and eye-piece removed, and in their place can be put a photographic plate-holder arranged to carry 4x5 inch plates.

There are three dispersion pieces. A very fine 5 inch diffraction grating by Rowland with 20,000 lines per inch is used for solar work. This is supported upon a table with adjustments to bring it normal to the plane of the optical axis, and it can be rotated to bring any portion of the spectrum of any order into the field of view. In place of the grating there may be substituted a single prism of small refracting angle, with silvered back, which furnishes by reflection a bright spectrum of low dispersion. It is used for observing the spectra of comets, nebulæ or other faint objects.

By removing the grating table and making some changes in the supports of the view-telescope, a box of prisms can be used for giving a high dispersion in stellar work. There is a system of four large compound prisms, each consisting of a prism of Jena glass faced with wedges of crown glass. The size of the faces of the prisms is 2½x3 inches, and the backs measure 4 inches long. The whole system can be adjusted for minimum deviation by a single motion. This angle for the violet end of the spectrum is about 165°.

All the adjustments of the entire instrument are made from the slit end by means of milled thumb screws, and the principal adjustments are provided with graduated scales to facilitate the setting of the instrument for any particular work.

The first photograph of a solar prominence ever taken was made

by Prof. Young in 1870. A collodion wet-plate was used and the time of exposure was about five minutes. After this the next photograph of a prominence was made by Prof. Geo. E. Hale in May, 1891. The method is a simple one. A prominence having been found the spectroscope is properly adjusted to it by observing it in the C line of the red end of the spectrum, the slit being either radial or tangential. The H and K bands of the violet end are then brought into the field of view; the photographic plate holder and dry-plate are substituted for the eye-piece, and with a wide-open slit an exposure of from five to twenty seconds is made. Upon development the prominence is clearly seen on the dark background of the H and K bands. These bands being very wide are excellent for this purpose. The fourth order spectrum is used to obtain very large dispersion. To obtain the spectrum of a prominence or the chromosphere it is only necessary to use a narrow slit instead of an open one.

Using the grating a number of excellent photographs of the spectra of the chromosphere and prominences were made at Princeton in August, 1891. Also a number of good photographs of sun-spot spectra, and of prominence forms were obtained. The chromosphere, prominence and spot spectra all show the constant and brilliant reversibility of the H and K lines, first seen visually by Prof. Young in 1872. Prof. Hale thinks the H and K bands in the solar spectrum, and the bright H and K lines in the chromosphere and prominence spectra to be due to calcium, and not to hydrogen as has been held heretofore. Prof. Young thinks it doubtful whether they are due to calcium though they are surely not due to hydrogen. The photographs show that the substance producing the H and K lines is projected into the extreme upper region of the sun's atmosphere, even above hydrogen. The photographs also show a group of bright hydrogen lines in the ultra-violet spectrum of the chromosphere which are characteristic as dark lines in the spectra of stars of the Sirian type.

The spectra of several stars have been photographed with a grating at Princeton. The exposure necessary when using the most sensitive dry plate is about half an hour. The principal lines are clearly shown. This is interesting as being the first instance in which a star spectrum has been photographed with a grating.

In April, 1892, Mr. Reed at Princeton obtained with the grating several photographs of the spectrum of Venus in daylight, which show clearly the displacement of the lines due to motion in the line of sight.

Besides continuing the very interesting and promising work on the sun, it is intended to extend the work to the study of stellar motions in the line of sight in continuance of the very valuable investigation of Vogel at Potsdam. Photography gives valuable assistance in this

line of investigation, for the displacement of the lines due to motion toward or from the observer according to Doppler's Principle, can be easily photographed and afterward very accurately measured. The accuracy of the method has exceeded all expectations. Vogel has studied carefully about fifty stars and has been able to throw considerable light upon the mechanical relation of several binary stars, and has shown conclusively that the variability of Algol is due to eclipse by a dark companion revolving about the bright star according to the laws of gravitation. Vogel's apparatus is being increased in efficiency, and soon a much larger number of stars will be investigated.

The four large prisms of the Princeton spectroscope, which are at present in the hands of the maker for a slight alteration, taken in connection with the large telescope of 23 inches aperture, will form a powerful instrument of research in this direction. Upon the whole we may confidently hope for very great developments in the near future in the line of Astro-Physics as the results of the combination of telescope, spectroscope and camera.

The paper was illustrated with about sixty lantern slides, many having been made from original negatives of recent date, specially to illustrate this paper.

AN ENLARGED WATERWAY BETWEEN THE GREAT LAKES AND THE ATLANTIC SEABOARD.

DISCUSSION.

Continued from Page 597, Vol. X.

By Wm. Pierson Judson, M. Am. Soc. C. E., M. Inst. C. E.

In the varied discussion of the projected enlarged waterway from the west and northwest to the sea, question has been raised of the practicability of the last link in the great chain.

The project for a Ship Canal across the State of New York, from Lake Ontario to the Hudson River, through Oneida Lake and the Valley of the Mohawk, has been met by the objection—fatal if proven—that water-supply cannot be provided for the summit-level in Oneida County near Rome.

The Rome summit-level lies across the lowest part of the flat ridge of earth which divides the valley of the Oneida and Oswego Rivers (flowing north and west into Lake Ontario) from the valley of the Mohawk River, flowing south and east into the Hudson. Its elevation is 182 feet above Lake Ontario and 428 feet above tide in the Hudson at Albany. Its water-supply will most readily come from lakes and reservoirs at the sources of the tributaries of both these systems, and

from such other streams, naturally flowing north to the St. Lawrence, as can be diverted to join them. Examination of the map would suggest Oneida Lake also, but it lies 60 feet below the summit-level and therefore is not available as a source of water-supply for it, though the deep water-way of the Lake is otherwise a valuable feature of the route.

Everyone familiar with the details of the present Erie Canal, (located upon substantially the same line) knows that there is, in dry seasons, lack of water for this same summit level, and this fact gives basis for the objection that water cannot be supplied for the Ship Canal, which must be five to six times larger. It is of vital importance that this objection should now be met. Congress is at present considering an appropriation for surveys of the route, one of the prominent features being to accurately determine the possible water-supply. The project will be forwarded, if assurance can be had now that a source of supply exists.

There is no question as to choice of the best general route, but rather whether the only one has the needed water supply, and what shall be the details of its construction and its cost, which probably will not vary much from one hundred million dollars for the whole route including the Niagara Ship Canal.

As to the construction, the natural conditions are evidently the most favorable for building such a canal. River channels being available for nearly the whole length. From Lake Ontario, the Oswego River can be canalized for 20½ miles to its junction with the Oneida River: Thence 14 miles of the straightened Oneida River leads to Oneida Lake, whose 23 miles of length lie in the direct line eastward.

From the head, or east end, of Oneida Lake to the channel of the Mohawk River at Rome, for a distance of 13 miles, is almost the only actual canal cut required, and this would naturally follow the valley of Wood Creek which flows into the head of Oneida Lake,—passing within a mile of the Mohawk River at Rome. It was across this narrow portage that the cargoes were carried for the Durham boats, which were the pioneers in the last century of the commerce between tide-water and the far west.

From Rome eastward, the channel of the Mohawk River can be rectified and canalized for 125 miles to its junction with the Hudson near Albany. The natural form of the river channel,—with its flat side-slopes and its wide water-surface,—will permit steamers to make more speed than in a narrow canal. Perhaps eight to ten miles per hour instead of four to five miles, with a corresponding saving of time and also of fuel.

The 428 feet of fall which the Mohawk makes in this distance, may be accomplished by some 18 dams and locks of 25 feet lift each. The great water-powers created at each of these dams, and available for

six or eight months of each year, will be features of importance for the manufacturing cities along the line.

This entire route from Lake Ontario to the Hudson—one hundred and eighty-five (185) miles—is remarkable in that it does not cross a single water-course. Not an aqueduct nor a culvert will be needed, and few draw-bridges; perhaps ten in all. This absence of expensive structures—costly both in construction and in maintenance—is in marked contrast to the conditions resulting from the parallel, but different, location of the present Erie Canal through the Mohawk valley.

Being of small capacity—72 feet wide and 7 feet deep—it was necessary to locate it out of reach of the spring floods, which would have overwhelmed it. It is therefore excavated upon or near the bank of the Mohawk, 20 to 30 feet above its ordinary level. There are thus required, at all the inflowing streams, aqueducts varying in length from one to 14 arches each to carry the trunk of the canal across the stream, besides 2 larger ones to cross the Mohawk itself, and there are also innumerable culverts for the smaller rivulets and drains, all of which must be allowed to flow beneath the canal-bottom into the Mohawk River, to which all the drainage of the region flows from the hills on either side.

By locating the Ship-Canal directly in the bed of the Mohawk River, necessity for all these structures will of course be avoided: the great size of the ship-canal enabling it to carry off the spring floods, which will pass before the season for navigation begins.

The main advantage, however, from the location of the Ship-Canal in the bed of the river, and one to which attention has not before been directed, is the great reduction in the amount of water used, which must result from such location.

The large loss of water due to the usual seepage or filtration from the canal-bed outward,being thus mainly,—and perhaps wholly avoided. The total amount of water usually to be provided for seepage and filtration, increases directly with the length of the canal and the area of wetted surface, and is a larger item than all the others combined when the experience with the present Erie Canal is taken as guide.

For the latter, it is reported to average 200 to 240 cubic feet of water per minute for each mile of canal. The Erie canal, however, as before described, is an embanked cut 20 to 30 feet above the neighboring Mohawk River-bed, into which its leaks must be many, since all the natural drainage is of course into the river channel.

The proposed location of the ship-canal, not only in the bed of the river, but much of it in a cut to be excavated several feet below the present river-bottom, seems to dispose of all reason to expect loss by seepage and filtration. With the present knowledge of the character

of the formations in the Mohawk Valley, it appears that no water will leak from the river-bed, but that all rivulets and rills as well as the recognized streams, will flow into it, and none from it. Certainly if there is any such loss of water, it will be at a minimum.

If this view is correct, it leaves only the lockage, the leakage of lockgates and the evaporation, to be considered, and these may be estimated to be as follows:

The total number of lockages which can be made in a day may be estimated at fifty: This will require that each lockage shall occupy less than thirty minutes. (The Sault St. Marie Lock, with its unequaled appliances, requires an average total of 40 minutes, including hauling the vessels into and out from the lock). Allowing two locks of water for each of the fifty lockages to and from the summit level, each lock being 500 feet long, and 60 feet wide and 25 feet lift, and converting this into cubic feet of water per minute, will be found to be 52,000 cubic feet.

Water for double this number of lockages has been sought in former estimates, but it is not apparent how a greater number can be made, nor that business for more can be expected.

Of the present Erie Canal boats, which carry 200 tons each, 12 could be passed at each lockage, or 600 per day, which is (8) eight times the daily average of the Erie Canal for 1890.

Of the present large upper-lake steamers carrying 2500 tons each, two could be passed at each lockage, or 100 per day, giving a canal capacity of a quarter million tons per day. This is six times the daily average of the Sault Ste. Marie Canal during 1890, or 12 times the daily average of the Suez Canal for the same year. Certainly this is ample to provide for now. This takes no account of the double duty received from a lockful of water when boats going in opposite directions use the locks alternately: In actual practice, it is found that two locks of water thus give three lockages.

For the next item, leakage of lock gates and valves, fifteen per cent. of the lockage water is ample, improvements in lock-gates probably reduciug it below this. Like the water for lockage, the leakage of gates is of course to be counted only once, each way from the summit: Both for lockage and for gate-leakage, the same water or its equivalent passes in succession from the higher to the lower levels, through any number of locks, and for any distance. This statement of the elementary principles of canal operation is evidently superfluous for the professional reader.

For the evaporation from the canal, the amount may be taken at a total, during the 120 days of summer, of 30 inches from the full width of surface; say 300 feet in the river sections. This gives an average loss by evaporation of 23 cubic feet per mile per minute, and for the

summit-level, 23 miles in length, this is 500 cubic feet per minute. For the other levels toward the Hudson, West Canada Creek, entering 5 miles further eastward, will more than supply for all evaporation, while Wood Creek and the tributaries of the Oswego River will supply the levels toward lake Ontario.

Summing up shows a total requirement of 60,000 cubic feet of water per minute, allowing nothing for seepage or filtration.

To meet this total we have the present supply of the Erie Canal at this point, which is stated in the Canal Reports to be 30,000 cubic feet per minute. To this may be added the flow of Fish Creek, now emptying into Oneida Lake, 7,000 cubic feet per minute: The former supply of the disused Chenango Canal,—900 cubic feet per minute,—can probably be restored if needed.

At the head waters of the Black River (which naturally flows to Lake Ontario, but a part of which now feeds the Rome level through the Black River Canal) there can probably be added water from the east branch of the Salmon, from which in 1887, Syracuse proposed to take in the same direction 1,500 cubic feet per minute.

The balance of the 60,000 cubic feet required, or much more if it should prove to be needed, can readily be provided by storage in the Adirondack Lakes and valleys along the headwaters of the Black, the Beaver and the Moose Rivers. The State has already formed fifteen reservoirs there, a portion however, being to restore to the lower Black River, water for canal supply taken from its head. The storage system is capable of indefinite extension in that region of innumerable lakes and ponds.

The subject is ably discussed by State Engineer John Bogart, M. Am. Soc. C. E., and by Asst. Engr. Aug. S. Kibbe, in the Canal Engr's Report for 1888, where the manner of making a large increase in storage capacity is detailed, and where the latter states that by simply guarding the existing reservoirs, the supply from them can be doubled or trebled. Those familiar with the Adirondack region know that from its peculiar position on the roof of the State, slight cuts and small dams will suffice to turn the direction of flow of many of its lake-chains, and that tracts which now drain to the St. Lawrence on the North, can readily be made to feed the Mohawk on the South.

In short, all available data confirm the impression that ample water supply can thus be provided.

To this conclusion, it may however be objected that, first, the supply from the Adirondacks cannot be so much increased; and second, that the demand will prove to be much greater than has here been estimated: Perhaps it will be said that the discarded item of filtration will alone require more than the total estimate.

As to the first, it may be said that Mr. Verplank Colvin, whose ex-

ceptional familiarity with the Adirondacks is so well known, writes in December 1891 "suitable reservoirs can be arranged to furnish all the water needed".

If the second objection is sustained by the surveys to be made, and the demand for water is then decided to be beyond the capability of the sources of supply which have been here indicated, such a decision will not show the canal to be impracticable.

It is entirely feasible, at reasonable cost, to bring from Lake Erie, water to supply the Rome summit-level.

This can be done by a feeder-branch, taken from the present Erie Canal near Macedon, 12 miles west of Newark, past which point Lake Erie water now flows. At this point the canal is 35 feet above the Rome level. The proposed feeder, instead of stepping down, as does the canal, can be swung off to the south to higher ground of the necessary elevation to maintain a uniform grade: going along the south side of the Clyde River and crossing the Seneca River near the Cayuga Lake outlet. The Seneca River Valley is here the narrowest, and the feeder could be carried across it in an open trunk upon a 40 feet to 50 feet trestle, about 2 miles long: The feeder decending thence, upon a regular grade of ½ foot per mile for the 70 miles necessary to reach the west end of the Rome level, just east of Syracuse.

Such a feeder of 8 feet depth and 38 feet bottom width in earth cutting, would pass 60,000 cubic feet per minute, or enough to alone meet the assumed needs.

To supply this would require some widening and deepening of the western portion of the present canal from Macedon through to Lake Erie and from Rome to Syracuse. This would greatly improve the efficiency of the Canal for continuing its present traffic, which would not be interrupted by the proposed Ship-canal.

It has been suggested that it would be as well to make a Ship-Canal through to Lake Erie as was proposed by Mr. Elnathan Sweet, M. Am. Soc. C. E., in 1884, in a valuable paper widely discussed then and often quoted since. The new line then first suggested for the canal enlargement, being in general similar to that here proposed for the feeder. But the making of such a small feeder offers few of the difficulties of construction of a great canal, which many engineers including the writer, consider to be out of the question upon this route.

Many irrigation feeders, some larger and some longer, are now in use in the Western States and are fully described by Mr. Herbert M. Wilson, M. Am. Soc. C. E. in a recent paper before the American Society of Civil Engineers.

That of the Kern Valley Water Co., is 125 feet bottom width with 10 feet depth of water.

The Bear River Company's feeder in Utah is now 60 miles long and is to be 150 miles.

The Idaho Company's feeder near Boise City is 70 miles long, 10 feet deep, and has a capacity more than twice that proposed for this Ship-Canal feeder.

The Turlock feeder in San Joaquin Valley is 98 miles long, 70 feet wide, with 7 feet of water.

As to the two miles of trestle and flume to carry the Ship-Canal feeder across the Seneca River Valley, there are now in California, carrying parts of the San Diego flume (a small one however) across valleys, 7½ miles of trestle varying in height up to 85 feet.

Summing up the foregoing facts it seems evident that from one or both of these sources, ample water-supply can be obtained for the summit-level of the Ship-Canal from Lake Ontario to the Hudson. It only remains to determine by exhaustive surveys, which is the better method, and what are its details, and these surveys can be made and reported upon during the present year if Congress will so order.

January 25, 1892.

SOPHUS HAAGENSEN.—A MEMOIR.

By Laurence Bradford and T. T. H. Harwood, Committee of the Boston Society of Civil Engineers.

[Submitted May 18, 1892.]

Mr. Sophus Haagensen, our fellow member, who died on the 17th. day of last December, was born in the City of Copenhagen, Denmark, on the 18th. of November, 1839. In accordance with the prevailing custom, at an early age he was christened in the State Lutheran Church and given the Christian names of Hans Sophus Andreas. The first and last of these he dropped on taking up his residence in this country. He was educated in the Civil Department of the Government Polytecnique School of Denmark, from which he graduated with the highest honors obtainable in the course of studies that he followed. Before graduating the Schleswig-Holstein war of 1862-4 broke out, when he obtained permission to leave for a time the university that he might enter the army, in which he was commissioned a Lieutenant of Artillery. In this war he served with credit and honor till peace was established, after which he returned to the Polytecnique, and completed his studies. After some experience on engineering works at home, he came to this country in 1868 and was engaged with the U. S. Military En-

gineers, first as draughtsman and afterward as Assistant Engineer, working for General George Thom, who was in charge for many years of a Department taking in the States of Maine, New Hampshire and Massachusetts. Mr. Haagensen's work was mostly on rivers and harbors, the work conducted by the Military Engineers under the River and Harbor Appropriation. He was thus employed for a number of years, when he left the service and engaged in private business, during which time he was a partner with the late President of this Society, Mr. Clemens Herschel, and together they had an office on State Street in this city. Later Mr. Haagensen returned to the government service, where he remained till his death. He was very ingenious in the devices which he originated, most of which he did not attempt to patent. He did, however, patent one, an automatic, self-recording sounding apparatus, which he invented in company with a compatriot, Mr. O. Sonne, a member of the American Society of Engineers. This was of cylindrical shape, and was designed to be towed along the bottom of bays and harbors, with mechanism inside which worked a pencil that traced a profile of the water bed, the vertical movement of this pencil being determined by the pressure of the water. This machine was successfully tried in the Harbor of Copenhagen, and was to have been further perfected by Mr. Haagensen and his partner. Mr. Haagensen married an American lady, who survives him with one child, a daughter.

As a man his manners were engaging, his address pleasant and cordial, his life without reproach of any kind, and many can testify to his acts of disinterested kindness, prompted only by a generous desire to aid where assistance was needed. In his death this Society has lost a creditable member and your committee a valued friend.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

BOSTON SOCIETY OF CIVIL ENGINEERS.

JUNE 15, 1892:—A regular meeting was held at Wesleyan Hall, Bromfield street, Boston, at 8 o'clock, P. M. President Manley in the chair. 45 members and 32 visitors present.

The record of the last meeting was read and approved.

Messrs. Henry W. Estey and Otto Sonne were elected members of the Society.

The Secretary read a communication from the American Society of Civil Engineers in relation to the Engineering Congress to be held during the Columbian Exposition and inviting this Society to name a member to aid the committee in procuring papers and arranging for discussions. President Henry Manley was selected to represent the Society in the matter.

The Secretary called attention to the vote passed October 17, 1888, by which he was authorized to use the 24 o'clock notation in notices of the Society meetings. On motion it was voted to discontinue the practice.

The Librarian submitted the following report, which was accepted.

Boston, June 15, 1892.

To the Boston Society of Civil Engineers.

The Committee on Library in their annual report referred to a proposed addition to the library by purchase. Since that time the books referred to have been purchased by Mr. Frederick Brooks, one of our members, and presented by him to the Society. This gift increased the library by 51 volumes which we did not have and completes some sets. They are mostly government and corporation reports. The most interesting portion is a series of 10 volumes of early reports on railroad, canal and government surveys, mostly previous to 1848, which had been collected and bound by Mr. William L. Dearborn, one of the first members of this Society.

For the Committee,

FRANK W. HODGDON, Librarian.

The President then introduced Mr. Walton I. Aims, C. E., of New York, who gave a very interesting account of the methods of tunneling used in the Hudson River Tunnel. His remarks were very fully illustrated by lantern views.

Mr. Howard A. Carson followed with an informal talk on the tunnel work now going on in connection with the Metropolitan Sewerage System and had thrown on the screen a number of views of the works in Chelsea, Charlestown and Somerville.

Mr. George S. Rice described the tunnel work in connection with the New Croton Aqueduct.

A general discussion followed participated in by Messrs. Brooks, Carson, G. S. Rice and L. F. Rice.

After passing a vote of thanks to Mr. Aims, the Society adjourned.

S. E. TINKHAM, Secretary.

Editors reprinting articles from this journal are requested to credit both the JOURNAL *and the Society before which such articles were read.*

ASSOCIATION OF ENGINEERING SOCIETIES.
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This Association, as a body, is not responsible for the subject matter of any Society or for statements or opinions of any of its members.

WHITHER IS OUR ARCHITECTURE TENDING?

BY CHAS. W. HOPKINSON, B. S. IN ARCHITECTURE, MEMBER CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read May 10, 1892.]

To the casual observer, there is much in the present condition of Architecture in America which is perplexing. The variety of style and proportion seen on every hand: the seemingly ever changing notion of what is proper in carving, in glass, in internal and external treatment, in painting, mason work and construction, has done much to befog the judgment regarding our existing architecture. Shingles the fashion now, mitered siding the fashion a little later, exterior plaster-work and even the slating of vertical walls, all of these struggling for prominence as a covering for the outside walls of our buildings. On our streets the same spirit is evident. The first residence may be colonial in treatment, with perhaps the four great columns, two stories high in front, fan lights over the front doors, and pervading all, the quaintness of a hundred years ago. Near this is a Gothic one with the steep gable and Elizabethan tendencies in mouldings, with perhaps, a touch of the chateau style of France about it. Or, it may be that a little farther down the street is a Romanesque residence with the round arch entrance and the massiveness and solidity of feudal times. And so the city over. The French say our facades are never monotonous. Of this there is no doubt in the least.

All this is very interesting as showing the inventive genius and resources of our architects. But we wish for a moment to look a

little deeper. To discover, if possible, some reason in it all and to inquire whither it is leading us.

That there is a reason in it all I am convinced, but because of the lack of appreciation of our position, I am convinced that much of the effort of the day is not fully understood.

The American modern system of designing is essentially eclectic. That is, the architects in different sections of the country largely work independently of each other; and this method has become so prevalent that there often seems no sort of sympathy in the designing of the several offices even in a single city. Nay, from the *same* office often comes work, as widely separated in style as the Gothic and Renaissance or the Colonial and the Swiss chalet style. The eclectic system has developed from several causes. One is that all the fundamental principles which enter into the different styles possible, are already well known. The cry of some for a new style—an American style, in any proper sense, can never be satisfied. Not that ideas are today lacking in our work; but simply because the possible ways of building and ornamenting are limited, and in their essential features are already known. How, for instance, may we span an opening? *First* by the lintel, as in the Egyptian and Grecian styles,—*second*, by the arch whether round, as in Romanesque, or pointed as in the Gothic. There are no more methods of support, all other possible ways are simply variations of these types. In the matter of sculpture and carving, the same difficulty arises. The sculptor or carver must either imitate or originate. If he imitates, he must go to nature for his models, but the artists of the world have been for centuries imitating nature. Can we excel the Greeks in sculpture; or the Gothic carvers in imitating vegetable life? If we limit ourselves to geometrical forms of decoration; can we hope to rival the brilliant efforts in this line on the walls of the Alhambra? No, an American style, in any such sense, is a physical impossibility. The best we can hope to do; and, indeed all there remains to be done, is to take one of the older styles, and adapt it to the requirements of our American environments.

Mr. Richardson, with probably some idea of introducing a style which might be called, more nearly than any other, an American style, attempted a development of the Romanesque. It has been fairly successful, but as to its effects on our present and future, I shall say a word later. Not all our architects chose to follow the lead of Mr. Richardson and attempt a systematic or continued effort in one line of development. To these any two methods were open. One was to adopt some definite style of the past and practice it, as copyists, simply, adapting it to our conditions; and the other method was to follow no single line of designing but pick and choose from all periods and styles, as the fancy dictates.

I might add that still a third class exists, if we may term it a class, consisting of those who, to some extent adopt the method of Mr. Richardson although not his favorite style and select some partially developed phase of some period in the past, and work at it independently of all other architects. But this last group of workers have been so flighty in their efforts that no continuous fruits such as have come from Mr. Richardson's work, have resulted. I therefore have generally given them rank with the eclectic designers.

Owing partly to the fact that our training as a body has not been sufficiently vigorous to enable us to appreciate the position of a follower of the masters of the thoroughly developed styles of the past, and partly because of the national desire to try something new, our architects have, until recently, avoided the method of accepting the old models and working from them, and have seen fit to work as individualists. There is one other reason why our work has been largely eclectic. American architecture until within 25 years perhaps, has been a second edition of English work. And even as England had its Renaissance, Queen Anne and Victorian Gothic periods, and then ran off into a jumble of all of them, so we had our Colonial, Queen Anne and Gothic, and in like manner ended by our being tired with nearly everything in the shape of a known style. Certainly, from the character of much that was done in this country and England, but more especially in America, from about 1850 to 1875, it is not strange that our architects became weary of their own efforts. It seems to me that the eclectic system, bad as it is, came as a profitable relief, rather than a curse, after our vain efforts to follow the lead of our foreign brothers who were quite as much at sea as ourselves.

Of the eclectic system of designing, Mr. Longfellow says: "It takes long to acquire it, and, once acquired, it is an individual faculty which dies with its possessor." This is no doubt true, and the wonder is that so much of our work of the last few years is as meretorious as it is. One great help towards keeping the work under this system from degeneration into wild experiments, has been the wonderful improvement in the technical journals, and the completeness of the interchange of news as to what the different men throughout the country are doing. But the fact remains, that, while the eclectic system of designing has largely continued up to date, yet our work is steadily increasing in real merit nearly everywhere in the country. It has almost seemed as though this method was what was necessary to put new life into the profession. I do not advocate the eclectic system in its fullest sense, as the best method of work, but simply that, at the time when English and American architects began it, the freedom from restraint which it allowed, was an advantage rather than a hurt. But a change is taking place, apparently the most of our architects

are still eclectics: yet, pervading the atmosphere is a greater respect than ever before for scholarly, careful conscientious work. This is in part brought about by the development, due to the architects publishing the results of their efforts, and partly to the higher educational standard of the profession. Never before since colonial times, and possibly a part of the time during the height of the Gothic revival in this country, has there been such an appreciation of pure Renaissance work: and I might add, of Gothic and Romanesque, as at present. It was during this inquiry into past models as furnishing a possible key towards lifting the general tone of our work to a better level, that Mr. Richardson introduced his Romanesque development. His genius was very soon felt, and by many, the Romanesque was hailed as the coming style. Aside from its characteristics of detail and general beauty, was a certain massiveness which was in sharp contrast with the proportions of much of the work during the latter part of our Gothic period and during our craze for iron architecture.

From this spirit of solidity and its characteristic round arch which produced the fine deep shadows so pleasing to most admirers of architecture, with the general delicacy and finish, and yet vigor of Mr. Richardson's handling of the Romanesque, it became a general favorite. But it was considerable to ask eclectic designers to give up their methods, and follow the new style. Few, if any did so entirely. The most of those who became the followers of Mr. Richardson, still clung to their eclectic work; and others who did not follow Mr. Richardson at all, were compelled to admit the influence of his work on theirs. At one time it looked as though, under Mr. Richardson's leading, we were to reach newer levels of architectural development, than had been reached for one hundred and fifty years; but his untimely death seemed to change the aspect. With his firm hand no longer leading, and his severely classical and scholarly training, working no longer for the uplifting of his chosen style, a change soon came. Gothic which had been seeking recognition once more, modestly asked that some of her delicate and beautiful ornament be adapted and used in connection with the Romanesque. This was done, and it was not long before even Shepley Rutan and Coolidge, the successors of Mr. Richardson, were departing from the teaching of their former employer, and were producing a combination which was no longer the pure Romanesque arch, *i. e.* of Angiovine, France, but rather, a Gothicized Romanesque. Personally, I was sorry, for I was curious to see how far the Romanesque could be carried by our best architects before reaching its period of fullest development. As it is, we shall have to wait for a worthy successor of Mr. Richardson, before we dare hope for it. The Romanesque style of today in Cleveland shows the characteristic to which I have referred, and also another tendency. It is that the

Renaissance style is again in the field, and is in better shape than ever before to create a lasting impression. It is crowding Romanesque quite hard: for, although, historically it is further away from it, than is Gothic, yet, in reality, it is very near in its underlying principles. As much of the present designing is Colonial or Renaissance in tendency, those who favor these styles, when the demand has been made upon them for something in the Romanesque, have found it more convenient to form the Romanesque-Renaissance combination, rather than the Romanesque-Gothic combination. But the Renaissance spirit, more especially, the Italian Renaissance, is in the land, and, is gaining ground quite rapidly. It was heralded and made possible through the introduction of and love for the Colonial style. It has now become so bold as to no longer hide under the cover of colonial architecture, but demands recognition as an independent candidate for honors. The success with which it has met can best be estimated by remembering that the whole of the main group of buildings of the World's fair is to be in the Renaissance style.

It is this crowding forward of Renaissance; and its mingling with the Romanesque, as well as the mingling of the Gothic and Romanesque, which make it extremely difficult to predict the future of the Richardsonian Romanesque movement. Whether it will be overcome by its rivals, is a question hard to answer. For myself, I believe that for many years to come, there will be a strong feeling of respect and admiration for the pure Romanesque. Certain it is, that however it changes as a whole, the round arch has come to stay: and the spirit of strength and security which Romanesque did so much to introduce and develope into all our designing, will remain as a permanent legacy of Mr. Richardson's life work.

There was a time when Renaissance as a serious competitor was laughed at, as a modern style, when it was said that its very laws and rules of proportion were against it; for a balustrade often became six or seven feet high, instead of three or four, and a bath room window often showed on the exterior with the same prominence as the drawing room windows. Yet now we see it adapted to modern work as easily as though it had always been as consistent as now. It has advanced with the times, and comes before us with the power to meet all demands in a manner better than ever. We have, I think, every reason to believe, that as yet, we are only at the threshold of an era of Renaissance work which, while following after the models of the real Renaissance of France, Italy and England, yet has in it the ring of the nineteenth century, and in its lines the feeling of a strong desire to meet the demands of the times. Once more must we turn our students to Vignole and the orders for the rudiments of scholarly work. Of all the signs of the times in the architectural world, I consider this,

one of the most hopeful, that we again sincerely study classic work.

I spoke of Gothic being applied to Romanesque. More than this has been done. It, like Renaissance, has found favor in the minds of people and architects, and each year sees an increasing amount of work done in it. Its spirit of dainty detail, and quaint lines, under the guidance of such men as Wilson Eyre, is pervading quite extensively certain classes of our work; so that, even if Gothic, pure and simple, should come back as a universal style, I believe it would be more refined, charming and sensible than ever before. Already a large proportion of the new churches in all parts of the country are Gothic; and it looks as though, as time goes on, we might expect the Gothic style to come back, at least as a church style. It is eminently fitted for this —more so, I believe, than any other known style and would, therefore, be a tendency in the right direction. As to its becoming a style for office and public buildings I do not fear.

The feeling is setting too strongly in favor of Renaissance as the style for such work, for that to occur. What seems probable is, that for the next few years, at least, Gothic may claim a large part of the church work, and Romanesque the remainder, and Renaissance the bulk of the public buildings, and possibly a part of the office work, except that in the latter branch I shall look for a strong Romanesque tendency, tempered it may be, as indicated above. The private work will follow in the make of all three of the styles, and their phases; although I think less so in the case of Gothic, than the other two.

But it does not seem likely, when we consider that no really new style can be developed, and we add to this our naturally inventive, and restless natures in matters of taste and art, that there will be any setting down to one thing definitely, for any long term of years. I believe changes will come; but that they will come more slowly, as we grow better acquainted with the resources of the various styles; and learn to see their beauty and usefulness.

The system of designing will continue, I believe, largely eclectic, although its worst features will be eliminated as the profession becomes familiar with the work of the past in a more scholarly way, and its libraries become filled with choice works treating of architectural history and models.

There will thus be less danger than ever before from this system, and we may fairly expect a higher grade of general excellence in design, thought and conscientiousness, than we have at present. With the splendid publications so complete on every hand, and training schools constantly sending into the offices young men with proper ideas, desires and theoretical training, and so many of our practicing architects so zealous to raise the tone of the profession, and to promote scholarly work; it seems highly probable, that whatever our future as

regards any particular style may be, the work, as a whole, will grow better and better, and more worthy the architecture of the most enlightened and progressive nation on the globe.

DISCUSSION.

PRESIDENT:—It is a very interesting paper, and I think worthy of discussion.

MR. PALMER:—I should like to ask Mr. Hopkinson what styles in his judgment are likely to prevail in the architecture of our private houses?

MR. HOPKINSON:—I would like to have some of the other architects take up the subject. I think I indicated, as fully as I dared, what the general opinion was, and should like to hear from some of these other gentlemen.

MR. HOPKINSON:—Professionally I think there is no special style, which is likely to prevail except that the Renaissance and Romanesque of all countries and the Colonial style, and the Swiss and Dutch, and everything else that is odd and quaint, and sometimes outlandish, are blending together: but there seems to be a lacking in the Gothic, although I think the Gothic ornament is going to be more largely used as time goes on than it has been in the past.

The Gothic ornaments are so beautiful, and as I said with just a touch of the spirit of Renaissance they become so extremly delicate, that I would like to see them carried on, and am sure they will be.

MR. COBURN:—I have not thought of saying anything about it, but it seems as though the delicacy and refinement of the classic style, was started throughout the country by the introduction of the colonial, about the time of the Centennial, (I think it was the Centennial Exhibition that started that style in vogue). It seems as though the delicacy of it was becoming more appreciated.

Along with that, it seems to me as though the constructive design that we used to think was found only in Gothic styles is being more introduced than we thought possible in classic work; and if that could be done and if we could only bring in to the classic work that constructive element so we might know it is truthful in spirit; that it was not merely something stuck on; if we knew that those forms really represented part of the construction, then we would affect the Gothic spirit.

It seems sometimes as though it was coming, and then on the other hand, we see so much that is copied; copied and built out of almost anything; copied from Greek, and copied from everything. Perhaps a good example is the building of the Columbian Exhibition Buildings out of stucco, all representing solid stone.

That is one thing we have got to get over; that is what seems to be an outrage, and we must get over it.

MR. RICHARDSON:—It seems to me that Mr. Coburn has set things before us as clearly as could be.

So far as American style is concerned, it seems we have that already, and do not know it. Those tall buildings at Chicago, there are no such styles in the world. One who is authority thinks that they show a very good handling of a very difficult problem, and it is very likely that the older buildings we admire so much, have been brought about by just some such condition as that. Possibly the Gothic architect may have reasoned in that way; because it is an entire departure from anything before.

All these buildings are simply pieces of very fine engineering; they do not pretend to architecture. You take the German Opera House at Chicago; just immense vertical lines drawn all the way up and down, and they look well. I would like to see it.

There is a building which looks like a tower; well designed. The lower part is very plain, and the upper part is quite rich. There never has been anything like that. These buildings will be looked upon as a new style.

I think if an American style comes at all, it will come as others did. Certain conditions will have to be met and the style will come, and I think if the architect would draw his work more as the engineer does, we would have something better, and not to decorate construction, but construct decoration. A certain gentleman says:—"Don't you employ an architect whatever you do; hire a good mason and let him put up the walls, and then hire an architect and let him put the face on". It has simply been applied.

I have great respect for McKim, Mead and White, but it sometimes seems as though they come very near acting upon this principle.

There is a building in New York called the Racket Club. It is construction decorated, instead of the other way. It is well our colleges are teaching these styles, and if we will study, instead of copying, and apply the principles with the problem in hand and then work it out, and try to bear in mind that other members of the building must have some, and we will get ornament and decoration enough. There seems to be a boom in putting phases on things, but that is simply a little classic and Colonial revival. I think the Gothic, and Romanesque and Renaissance will remain.

MR. HERMANN:—Although I am not an architect, and do not know much about it, but the remarks that are made here remind me of the difficulties in the way of a new style, which shall be a distinct American style. I do think that is coming, and in the shape of what the Germans call "utility construction". In the old country there are

very large Government buildings for the housing of soldiers, (barracks in English). These buildings have the object of getting as many sleeping rooms together as possible. The buildings are very large. Some of them are built with regard to defense in case of a riot. Sometimes some of those buildings are 1000 feet front. I do not think any Architect could qualify them, still they are great buildings. They have a peculiar beauty of their own. Now, those big buildings in Chicago and New York are something of that character: still they work out the same details in very large proportions.

That there is a chance for a new style as I say, (although I am not an architect nor an artist), it seems to me that the present and future can create, and if we would look over architectural work, we would find that each of them have something peculiar and distinct. I say, it doesn't seem to me that we are bound to what has been done, and cannot create anything new.

Mr. Hopkinson:—In New York City men are trained in the college work as well to base all their decoration on construction, and I think everyone who comes from New York believes that.

I am glad that the idea is growing, and I know that Cleveland architects are right in line.

Utilitarian architecture, being based upon construction, is dignified and imposing in ware-house work, and in buildings where there is no architectural beauty. It has a sense of beauty that comes from the fact that it is largely utilitarian and based on construction. That is a clear point to start from; but I wish to say with regard to much of our Gothic and Renaissance detail that much of the Renaissance was grotesque, and the Gothic almost as grotesque. Much of it has the form and idea of Gothic Carvers' Work, but not the spirit of delicacy because most of the Gothic was in the air, and when it was brought down it lost its delicacy and in many cases in copying this was not sufficiently taken into account. The extreme delicacy of the American handling of subjects I do not think can be attributed to the old masters. I myself cannot see how we can originate a style. All we can do is work in the lines of other schools. It is as though you went around a circle and then asked for more. If we went to India we couldn't find anything very different in principle but we can throw our individual nationatity into some one of the phases of the past and make it an architectural school, which is strictly American, and that is all we can do. It is in that line that we can hope to do something original.

Mr. Hermann:—When American machines were first designed, a wooden frame gave the shape of the machine, and even long after iron was employed to shape the machines, it was all a copy of the woodwork. It has within the last few years changed entirely.

Forms and changes that were never thought of are now used on the machines of today; look different, and have a style peculiar to themselves, but I do not think that any architect would call them homely, although they are very plain: but there is a peculiar style which differs entirely from what has been used twenty years ago, and I do think the same ought to be possible in buildings.

Mr. Warner:—We would like to hear from Mr. Searles; we would like to have him tell us about the bridges of New York.

Mr. Searles:—Mr. President, my name has been mentioned, and I feel it a pleasure to respond, although it is premature to say anything about the architecture of New York bridges. The one great bridge which has been for years the success across the East River is probably well known to all the members. The bridge as viewed from any standpoint, I think, commends itself to the good taste and best judgment of the beholder, either from the land or from the water. It is graceful, strong and airy, and undoubtedly useful to the last degree.

The other bridges, which are as yet unbuilt, we can say but little about. The bridge with which I have had some connection, which is designed to span the East River at 23rd St., New York, I think will at least equal in beauty the East River bridge.

The design as now completed and on file in the office, has masonry foundations down to the rock, surmounted above the water by steel towers, which are very graceful in design. These have been published in some of our journals, that is the designs have been. The floor of the main span is supported by an inverted or suspended arch.

The arch, however, is constructed of wire: an endless skein, like that of the East River bridge so far as the building of the cable goes, but differing in another respect, in that the wire is not carried continuously from anchorage to anchorage, but is about in three distinct skeins; one passing from tower to tower across the river, and another over the east half span, and the other on the west half span.

The skeins are suspended from steel pins, the cable losing its circular section near the pin, and spreading out into strands, so that they can pass over the pin and occupy considerable space on the land. These strands are interlocked with the strands of the main span. It is proposed to have a steel pin twenty-five feet long, and 40 inches in diameter, and made hollow. This is a wide departure from any previous suspension bridge.

This would appear to make no allowance for expansion and contraction due to temperature, but it is only the difference in expansion between the half of the middle span and the main span that has to be accounted for, and this is so small that it can easily be taken up in the steel towers which will be 600 feet high.

Nothing has really been done as yet towards construction, because

so much is first necessary in regard to legal status, and right of way on a large amount of property. Proceedings are in progress for condemning land where purchase could not be made, and it is probable that within twelve months from this time, and perhaps much less, some engineering work will be undertaken on the ground.

Without going into the details as to dimensions, I will just say, gentlemen, that the main span across the river will be not less than 3000 feet long and 125 feet in width. It will accommodate, on the main floor, eight (8) tracks of standard gauge, for express trains, and it will have a second floor, or deck, which will accommodate six (6) tracks. It is exclusively a railroad bridge, not intended to have wagon travel; it may possibly be for pedestrians, as it will be an object of interest and an attractive work, after the study that has been put upon it. I may say that the difficulties in the way are not in engineering feat, but in securing the harmony of all the different railroad companies that will be interested in it; of all the different classes of people that are interested in it. The harmonizing of these interests affords a much more difficult problem than that of civil engineering, as this is already solved.

THE PRESIDENT:—I would like to ask what grade of steel would be used in cable of that sort?

MR. SEARLES:—There will be a steel wire, but as to the grade I do not think the specification has yet been written, because we are learning all the time, and the very latest and most approved method would be adopted.

The history of these bridges is something like this:—As long ago as six years, 1886, I think, Mr. Lindenthal first moved in this matter of the Hudson River bridge. He is entitled to the first suggestion of such a structure, and really to all that has been done towards it since.

It was at the instance of some of the large Trunk Lines that he commenced this study, although it has taken a different shape since, and there now is organized a Bridge Company, having its charter directly from the United States Government as a Post road, and as the means of commerce between states, and the work has gone on with the usual difficulties encountered in such a great work; but the idea was later taken up by another company, which is known as the New York and New Jersey Company. This is composed of a number of New York gentlemen who are best known in the Political field, and they keep themselves constantly before the public. You may have noticed in the public press their doings on all occasions.

This New York and New Jersey Company, before it had any design for a bridge, received state charters, but to this day they have no legislation to permit them to cross the river.

The North River Bridge Company, of which Mr. Lindenthal is chief

engineer, a year ago last July, obtained full authority to organize as a company, and to build its bridge subject to the approval of the Secretary of war as to plans.

These have been submitted to and passed upon by the Secretary of War and finally approved, and everything is in good shape. The charter carries with it not only the power to cross the River and build on either side, but also to condemn land as may be necessary by the usual process in the United States Courts, but following the laws of the states in every case.

The New York and New Jersey Bridge Company worked a year ago during the whole session of Congress to secure a favorable report in regard to their bridge, and were unable to get it. They worked again all this session of Congress, and have finally, within a few weeks, obtained a report from the committee, the bill is now before Congress.

Mr. Warner:—Would it not have been cheaper to build the bridge with a central pier?

Mr. Searles:—From an engineering point of view, undoubtedly it would be economical to put a pier in the river, but the company was not permitted to consider that matter as the government refused to have any pier in the river; if the bridge could not be built without a pier, it was not to be built, so that the engineer is forced to consider a single span and to adapt the material to the necessity of the case. Two spans of 1,500 would be very much cheaper than one of 3,000; nevertheless, the 3,000 foot span can be built at a not unreasonable expense. We havea table of figures, showing what has been the price per lineal foot of track on bridges in Europe and America and it is a fact that this bridge will cost but very little more per foot of track on it than other railroad bridges. The tracks will be occupied and put to service, and so the bridge will not have an excessive cost, in comparison with the business it will do.

Mr. Coburn:—I would like to enquire something about the number of skeins, and about how large they are?

Mr. Searles:—I used the word skein merely by way of illustration. These wires will be suspended from one pin to the other. They will be sheathed with steel plates for protection against the weather. The cable is four feet in diameter and the height of the truss 50 feet and thoroughly braced from end to end, and on pin connections.

The wires at the intersection points of bracing widen out a little, just enough to get around the pin which is provided for. Of course, all the details I cannot go into here, but this is the general idea, that the chords of the suspended arch are wire and in cable form; nevertheless they are kept in place by stiff bracing on pin connections, and one massive pin at the top of each tower supports all the strands.

The case of the Washington bridge over the Harlem River is just

this case reversed. The thrust there is all concentrated on one pin at the abutment.

MR. HOPKINSON:—What is the strength of the Brooklyn Bridge as compared to the new bridge?

MR. SEARLES:—The Brooklyn bridge cable is about 14 inches as against 48 in this. There are 4 cables in each case; the difference in the section of the cables indicates, in a measure, the difference in the strength, but the Brooklyn bridge is doing all it ought to do, and it is carrying its trains of small cable cars, and the wagon traffic and foot traffic, while the North River Bridge is intended entirely for railroad traffic. As the trains come across the country from Philadelphia, and other points they will go right across the bridge without slacking speed into New York City. The weight of the bridge itself is so great that the additional weight of the trains is of less importance than it would be in a smaller structure.

MR. RICHARDSON:—I would like to ask Mr. Searles in what way are the ends of the single wires connected?

MR. SEARLES:—It is proposed to connect these by electricity. In the East River bridge the wire ends were connected by a sort of sleeve-nut, but at the present day the electric weld is all that is necessary.

MR. RICHARDSON:—How high is this pin in the tower; how high from the water?

MR. SEARLES:—About 600 feet. The bridge is to clear the water 150 feet at the center.

MR. HOPKINSON:—I would like to ask if when the life of the Brooklyn Bridge ends, they will try and replace the cable, or will they have to take the whole bridge to pieces, or what?

MR. SEARLES:—I don't know. One of the oldest bridges in the country; one of the first suspension bridges ever put up was at Philadelphia, across the Schuylkill River, and that was taken down a few years since, (I cannot give the dates), and the wire which was in the cable, when released, sprung into a circle again like the coil it was originally wound in, and apparently it had only commenced its life; what it would have been in old age, or when that would have happened I cannot say.

MR. HERMANN:—In regard to the life of suspension bridges I do not know, but in France every 14 years the bridges have to be tested. I know of one instance where one bridge was tested and the cable-anchorage was corroded and broke. The bridge was not a wire suspension bridge. In Bavaria they also have a law enforcing the testing of bridges, but I think that present engineering has got over this. My impression is that the wire would last indefinitely if protected from the weather, and if the strain was on the inside, I should think it would be almost impossible to limit its life.

Mr. Porter:—I would like to know if it is not the custom in this government to require steel that will stand a strain of 200,000 to 300,000 pounds to the square inch. When Mr. Lindenthal read his paper before the American Society, I think he mentioned the fact that probably this bridge would be made of steel that would stand a strain of 180,000.

I saw a statement in the paper that a suspension bridge at Cincinnati is to be replaced by a new bridge: probably it will be a truss bridge. As I understand it, it is on account of the injury to the cables, probably from the failure to keep the water from getting among the wires. I think if water gets in, it makes short work of this.

A Member:—I think these cables were tested, were they not?

Mr. Porter:—Yes, sir.

A Member:—They were found to stand up to the original test?

Mr. Porter:—Yes, sir.

THE WHEEL RECORD.

By J. N. Barr, Member Wisconsin Polytechnic Society.

[Read May 9, 1892.]

There is possibly no point that has a more important bearing on the economical administration of the affairs of a railroad than the records. These may be divided into three classes.

First, we have the financial records which have always been a necessity from the very nature of the case and which are frequently carried to a high degree of perfection as illustrated in the Annual Reports of many railroads.

Second, we have the class of records necessitated by the requirements of special classes of work. The Car Record is a very good example. This very elaborate and expensive record is maintained on all roads chiefly because it would be impossible to maintain the efficiency of the transportation department without its use.

Third, we have the class of records which are not required by any financial or administrative considerations, but which have for their object, that of securing greater efficiency and economy in the administration of any particular department.

It will no doubt be admitted at once that unless a record of this kind really gives such information as will lead to greater economy or effectiveness in the operations it records, it is valueless; and unless it effects a greater saving than the cost of maintaining it, there is no reason for its existence. A railroad company is strictly a money-mak-

ing and money-saving concern. There is nothing in its intention that will justify the maintenance of a record merely to satisfy curiosity, or to establish points of abstract scientific interest. This may seem a self-evident proposition, but a careful observation on any road will almost invariably reveal the fact that there are records which, if they are not maintained merely for curiosity, do very little toward effecting their legitimate object, that of affording information that will be of actual practical value in determining the weak and objectionable points in present practice and pointing out improvements for the future. For example, many roads make reports of broken axles, and some sort of a record is kept of the same, but of what possible service can such a record be unless the character and location of the fracture is given, as well as the size of the axle and the load carried. With this additional information, the record will determine the proper limit of size for the axle, for a given load, without it, we discover simply that so many axles have been broken in a given time.

With these preliminary remarks I will pass on to the description of the wheel record, and will endeavor to show what it has taught, what it may yet teach, and wherein it does not and cannot give the information necessary to a thorough comprehension of the entire problem which it attempts to solve.

In the first place it will be necessary to give some idea of the subject matter with which the record has to deal. A more or less adequate conception of the qualities of a wheel and the circumstances attending its service is absolutely essential in devising a wheel record and the more comprehensive the knowledge of these points, the more nearly perfect will the record be.

To the casual observer, noting the operations of making chilled cast iron car wheels, the same will appear as a mass of metal of the proper size and shape with the parts that come in contact with the rail chilled or hardened to increase its durability, and after observing the fact that the operation of chilling transforms the originally gray iron, for a certain depth from the chilling surface into a briliant white and intensely hard metal, a somewhat more definite idea would be formed. The idea of the wheel would then be a mass of metal of the proper shape and size, the body of which is composed of gray cast iron, the parts in contact with the rail being formed of a shell of hard white iron. The tread of the wheel and inside of flange being formed against a chill carefully trued up in a lathe will naturally be supposed to present a true cylindrical or conoidal surface to the rail. The wheel as described above may fitly be termed the ideal wheel, and it is ideal in more senses than one. If now the observer with this amount of observation were to attempt to devise an adequate wheel record, the results to be obtained from it as a device for effecting greater econ-

omy, would be to say the least, not flattering. Such a record would show that in a given year a certain number of wheels making a certain mileage had been condemned. It might show the comparative merits of different makes of wheels, but even here its teachings would have to be regarded with distrust, for the results might be very misleading, as will be shown hereafter. Precisely similar results could be obtained by keeping a simple account of the number of wheels of each kind used and the number drawn, without taking mileage into consideration.

A more extended series of observations will however develop the fact that in practice the ideal wheel is seldom or never realized and that the departure from the ideal varies in different makes of wheels and more or less in wheels of the same make.

These departures may be classified as follows:

1. Lack of roundness.
2. Variation in thickness of shell of white iron.
3. Imperfection in the white iron.
4. Lack of requisite strength.

Lack of roundness is an imperfection which is not readily observed as the departure from a true conical surface is so slight as not to be perceptible to the eye. The fact, however, is revealed at once on revolving a mounted wheel on centers and presenting a stationary pointer to the tread. It will also reveal itself to the observer standing beside a moving train of cars, some of the cars being equipped with new wheels. The new wheels will at once make the fact of their newness apparent by the increased rumbling as they roll upon the rail.

Variation in the thickness of the shell of white iron on which the durability of the wheel depends, will be perceived at once on breaking a wheel. One wheel will be sufficient to demonstrate this fact, but careful observation and measurement of a large number of wheels will be required to show how serious and all pervading this imperfection is.

Imperfections in the white or chilled iron are not at all obtrusive in manifesting themselves and are generally so minute or indefinite as to escape attention until the attention has been educated and directed by observation on the manner in which wheels fail in service.

Lack of requisite strength can only be determined by carrying observations further than a mere inspection of the wheels allow. The actual test in service is necessary to educate the judgment in this matter.

Having now obtained a general idea of the peculiarities that manifest themselves in car wheels, of the departure from the ideal, a record devised with this amount of knowledge would doubtless give much more satisfactory and valuable results, and yet without a knowledge of the manner in which wheels in service actually fail, and the influ-

ence of the various classes of service on the life of a wheel the record would in all probability be far from adequate. It will therefore be in order to consider these two points briefly before determining on a form of record.

As to the manner in which wheels fail in service a careful consideration of what has just been said on the imperfections in cast iron wheels, would no doubt point out partially how wheels actually fail, but it would require little less than prophetic power, to deduce and formulate the manner in which wheels fail from mere observation of the wheel itself. Turning from the new wheel, however, to the scrap pile, we find a full answer to this question.

Here it is found that wheels fail or are condemned principally from four causes:

1st. Failure of the shell of chilled iron.
2nd. Abrasion.
3rd. Breaking or Fracture.
4th. Application of brakes.

Under the head of "Failure of Chill" there are four distinct forms which manifest themselves; three of these are due to disintegration of the white iron and are termed "Shelled Out", "Comby and Seams". The fourth form is caused by wearing through the shell of white iron where it is thinnest and is distinguished by the term "Worn Flat".

The failures due to "Abrasion" may be classed under two heads, "Worn Flange" and "Tread Worn Hollow", but in nearly every case in which a wheel is condemned on account of tread being worn hollow, the wear is not evenly distributed over the tread but occurs, either close to the flange or out on the tread, entirely removed from the flange. It has therefore been found convenient and useful to distinguish between these and use two terms, "Tread worn hollow at Flange" and "Tread worn hollow from Flange."

An inspection of a number of broken wheels reveals the fact that each particular form of pattern has to a great extent its own peculiarities as to manner of breaking, but the wheels under this head may be classified as follows: "Broken Flange", "Broken Rim", "Cracked Plate", "Cracked between plates", "Burst" and "Broken in pieces."

Under the head of wheels condemned on account of application of Brakes, the one term "Flat from sliding" is used.

The above mentioned small list of defects really covers the whole subject and when carefully applied in a record, will give definite information as to the condition of condemned wheels.

With regard to influence of service, it can only be said at this point that no definite results can be obtained as long as it is attempted to consolidate the returns from wheels of different sizes, or from wheels

Statement showing defects of cast iron wheels as influenced by kind of service during 1890.

CLASS I. (CHILL FAILING.)

KIND OF SERVICE.	Dia. of Wheel.	SHELLED OUT. No.	SHELLED OUT. Average Mileage.	SHELLED OUT. %	COMBY. No.	COMBY. Average Mileage.	COMBY. %	SEAMS. No.	SEAMS. Average Mileage.	SEAMS. %
Passenger.	33	148	92007	16.8	1	92307	0.1	12	99868	1.4
B. M. & Ex.	33	178	98891	22 7	—	—	—	11	113850	1.4
Parlor & Sl'per.	33	7	91517	36.8	—	—	—	—	—	—
Engine Tender.	33	1277	60724	53.	6	87100	2.	18	97498	7.
" "	30	38	65472	41.8	—	—	—	1	35702	1.1
Engine Truck.	30	390	48664	49.2	2	30580	0.3	15	83860	1.9
" "	28	316	40771	53.2	7	40771	1.2	4	60161	0.7
" "	26	13	31001	27.7	6	31001	12.8	—	—	—

Statement showing defects of cast iron wheels as influenced by kind of service during 1890.

CLASS II. (WEAR ON RAIL.)

KIND OF SERVICE.	Dia. of Wheel.	WORN FLANGE. No.	WORN FLANGE. Average Mileage.	WORN FLANGE. %	WORN TREAD. No.	WORN TREAD. Average Mileage.	WORN TREAD. %	WORN FLAT. No.	WORN FLAT. Average Mileage.	WORN FLAT. %
Passenger.	33	67	97413	7.6	61	119263	6.9	4	105547	0.5
B. M. & Ex.	33	65	110426	8.3	59	125168	7.5	7	115025	0.9
Parlor & Sl'per.	33	3	77030	15.8	1	153145	5.3	—	—	—
Engine Tender.	33	318	80362	13.2	56	107167	2.3	49	121768	2.
" "	30	3	99570	3.3	5	100562	5.5	23	69610	25.3
Engine Truck.	30	210	55594	26.5	16	88136	2.0	10	69020	1.3
" "	28	100	55918	16.8	17	59366	2.9	9	61075	1.5
" "	26	2	52201	4.3	—	—	—	19	41701	40.4

Statement showing defects of cast iron wheels as influenced by kind of service during 1890.

CLASSES II. & III. (WEAR ON RAIL AND BROKEN.)

KIND OF SERVICE.	Dia. of Wheel.	WORN HOLLOW AT FLANGE. No.	WORN HOLLOW AT FLANGE. Average Mileage.	WORN HOLLOW AT FLANGE. %	WORN HOLLOW FROM FLANGE. No.	WORN HOLLOW FROM FLANGE. Average Mileage.	WORN HOLLOW FROM FLANGE. %	BROKEN RIM OR FLANGE. No.	BROKEN RIM OR FLANGE. Average Mileage.	BROKEN RIM OR FLANGE. %
Passenger.	33	171	91511	19.7	49	106020	5.5	12	115583	1.4
B. M. & Ex.	33	146	99594	18.6	55	115797	7.	14	118868	1.8
Parlor & Sl'per.	33	6	102016	31.6	—	—	—	—	—	—
Engine Tender.	33	259	82936	10.7	113	103369	4.7	67	89332	2.8
" "	30	4	39527	4.4	2	39957	2.2	8	90773	8.8
Engine Truck.	30	37	62197	4.7	16	61671	2.	17	30272	2.1
" "	28	26	45807	4.4	14	49202	2.4	6	49601	1.
" "	26	—	—	—	—	—	—	2	35881	4.3

Statement showing defects of cast iron wheels as influenced by kind of service during 1890.

CLASS III. (BROKEN.)

KIND OF SERVICE.	Dia. of Wheel.	CRACKED PLATE OR BRACKETS.			OTHER DEFECTS.			TOTAL.	
		No.	Average Mileage.	%	No.	Average Mileage.	%	No.	Average Mileage.
Passenger.	33	1	104001	0.1	354	46994	40.1	883	77437
B. M. & Ex.	33	—	—	—	250	49690	31.8	785	88629
Parlor & Sl'per.	33	—	—	—	2	5940	10.5	19	86780
Engine Tender.	33	1	33288	—	247	44928	10.2	2411	69482
" "	30	—	—	—	7	46560	7.7	91	68306
Engine Truck.	30	—	—	—	80	58664	10.1	793	53679
" "	28	1	9279	0.2	94	58552	15.8	594	47523
" "	26	—	—	—	5	52344	10.6	47	39604

of the same size, under cars or engines, varying much in weight or speed.

We have now taken, as it wêre, a flying observation of the qualities of car wheels in general, of the manner in which they fail in service, and have the fact that the character of service exerts an important influence on the mileage of wheels. An adequate wheel record will give accurate information on all these points and from this information a correct idea of the merits of the wheels should be obtainable. If a railroad company does not make its own wheels the question is much simplified. But when wheels are also made, the question is further complicated by records of material used and foundry manipulation, but this part of the record will not be considered.

Bearing the above facts in mind, we are now prepared to take up the consideration of the wheel record itself. In doing this it is not proposed to enter into a description of the varions blanks used for the purpose of collecting the information, or to discuss the minutiæ involved in compiling the information and putting it into shape, as that would be much better comprehended by a few hours observation of the actual work in the wheel record office.

In entering on this description, it will possibly be most interesting to give a short sketch of the origin and development of the wheel record, so far as my experience goes, and this will no doubt give additional point to some of the preceding remarks.

When the wheel record was first established, reports were made weekly from each shop, of all wheels used under and drawn from passenger equipment cars and from engines. These reports gave the wheel number, the date cast, the car number and the condition of the wheels drawn. The mileage of the wheels drawn was ascertained from the record of Car Mileage. At the end of the year a statement was

made of the mileage of wheels drawn. This statement showed the average mileage of wheels of the same size drawn from passenger and freight engines collectively, giving each make of wheels separately. Each man reporting wheels used his own discretion as to the best manner of describing the condition of the wheels drawn. You will notice here that a distinction was made between the service of wheels under cars and under engines. This was a step in the right direction, but as you will see further on it did not go far enough, and the maker who was fortunate enough to have his wheels placed under freight engines, had about two thousand miles in his favor, as compared with the same quality of wheel placed under passenger engines. The record was continued in this form for several years, but in a short time there was a distinction made between wheels under passenger engines and freight engines. Soon a separate statement was made for wheels drawn from Pullman Cars. Many of the wheels reported found their way to the wheel foundry and an endeavor was made to compare the condition of the wheel with the reports from the road but met with a repulse at once from the formidable array of terms used in describing the condition. For example, the condition of the wheel designated by the term "Shelled out" was described in the weekly reports by the following terms; Rough, Worn out, Bad manufacture of chill, flaw on tread in casting, sand holes, Bad chill, Worn in holes and Flaws. Each shop had its own pet term, and in that case the same term did service for almost any condition of wheel. In view of these discrepancies a circular* was issued, by our company which, required inspectors to use the terms before mentioned and none other. This certainly resulted in a great reduction of the number of terms used on the weekly reports, but the men were not inclined to use this term with sufficient discrimination to guarantee strict accuracy and the old tendency to a fondness for the use of some particular term began to manifest itself.

After the wheel record had been in operation about five years, one of the most important steps in the history of the record was taken. It was required that all condemned wheels drawn during any month should be shipped to the foundry before the tenth of the succeeding month. These wheels were all inspected on unloading them from the car, and the report of the condition of the wheels from this inspection placed on the record beside the report from the road. All discrepancies were promptly reported to the inspector responsible for the same, and in a short time such discrepancies were few and far between.

In addition to securing more accurate records, another and extremely important result was accomplished; the proportion of wheels found to be good for further service increased enormously.

*"Instructions for using and Repairing Wheels and Axles." Chicago, Milwaukee & St. Paul Railway Co., December 1, 1883.

A distinction was made between the mileage of wheels drawn from Baggage, Express and Postal Cars and the ordinary Passenger Cars, including Combination and Emigrant Cars.

This was the last important change made in the record.

In addition to the regular weekly reports on which the record is based, a special report is made of each wheel found cracked or broken. These reports give a full description of the nature of the fracture and the direction of train as well as the nearest station to the point the fracture was discovered.

In order to illustrate the above remarks, a copy of the Annual Report of wheels removed and scrapped on the Chicago, Milwaukee & St. Paul R'y for the year ending Dec. 31st. 1890, is attached. This statement shows the number of wheels removed from each class of service and the average mileage of the same; also the number removed for each defect and the average mileage, also the percentage of wheels removed for each defect. In comparing wheels of different make or wheels of the same make for different periods of time, a decrease in the percentage of Shelled out, Comby, Seamy and Worn flat wheels, or an increase in the mileage of wheels condemned for these defects, indicate the better wheel. A perfect wheel should only wear out by wearing the flange thin, or wearing the tread hollow, therefore an increase in the percentage of wheels condemned on account of Worn Flange or Tread worn Hollow, or an increase in the mileage of the same, indicates improvement.

I will not trouble you with the details of the various reports from which this statement is compiled, but would say in any branch of work, mere reports that are not properly compiled are likely to be of very little service.

DISCUSSION.

Mr. Geo. W. Goetz:—I am sorry that Mr. Barr is not here, as I was anxious to hear some discussion relative to the matter of steel wheels. Of course, I take that side of the question, while Mr. Barr is inclined to cast iron. I hope the day will come when we will have our wheels made of steel. It seems to me that one objection to the chilled iron wheel would be the strain that must result from the surface being so hard while the interior stays soft, there being an entirely different chemical composition in the parts. I understand that provision is made for taking out this strain, but it seems to me that a great strain must remain. I have no records of steel wheels, but I know they will outlast the other by far, and it is only a matter of figures to find out which is cheaper. There is a growing tendency to the use of steel

wheels: most of the wheels on the New York elevated lines are of steel, and so the ground is gradually being conquered. Of course, it takes some capital to use steel wheels; it takes less capital to use iron wheels, but in the long run I think it is cheaper to use steel wheels, although I suppose in this Mr. Barr may not agree with me. I know that the use of steel wheels is increasing. In 1884 we had one furnace running on steel wheels; now there are at least two large furnaces in Cleveland, and I do not know how many in Pittsburgh, Midvale, and other places. There must be between 15 and 20 big furnaces making steel wheels, so you will readily see how this has increased in the last few years. In Germany they use steel wheels, but in Austria iron wheels are used. I noticed when in Europe last summer, at a little place on the border between Germany and Austria, that they unloaded the goods from an Austrian car on to a German car, and on inquiring into the reason for this, I found that they would not allow the Austrian car with cast iron wheels on the German road, as it was not considered safe. They have had a great deal of discussion on the matter over there. Of course, over there, the conditions are entirely different, and they have never been in the same position as we are. Charcoal iron is peculiarly adapted to the making of chilled wheels, the conditions necessary being low silica, say one per cent., and high carbon. As soon as silica is 1 ½ per cent., the chilling does not take place at all. Over there they cannot make low silica iron with high carbon, but we can. Charcoal being cheap, we can make chilled wheels here, but the price of charcoal is rising steadily, and the day is coming when we cannot use charcoal iron so freely. I think everybody will admit this, when you consider the amount of wood that a charcoal furnace uses per day. We are bound to come to the steel wheel, even if the record were not as good as that of the chilled wheel.

MR. BENZENBERG:—I am sorry that Mr. Barr is not here, but if he is present at our next meeting, I will be glad to call up the discussion at that time. As I said before, it seems to me that his record here demonstrates one fact, that the record which they have and are working under is as yet a very imperfect one, because the defects that very materially reduce the service in average mileage and represent a large proportion of the number of wheels drawn from service are apparently from unknown causes.

MR. HATHAWAY:—Does not the heading "Other defects" refer to defects in casting aside from wear?

MR. BENZENBERG:—It includes all general defects, other than those specified under the various headings, and under this head there is apparently the largest deficiency in mileage service.

MR. GOETZ:—I think you will find the mileage service of steel wheels to far exceed that of iron, though I have no exact figures on

the matter. Our experience has been that in order to get a good chilled roll there should be a certain amount of phosphorus in iron, because the phosphorus makes iron fluid, but in case phosphorus is missing, the contraction is so strong that it brings out little fine lines. when the least strain would break a big roll. I heard a party connected with the Pennsylvania R. R. say that they had found that it is good to have a certain amount of phosphorus in a chilled wheel. I should imagine that these chill cracks would be largely a cause of failure in wheels.

MR. BENZENBERG:—I do not know whether Mr. Bentzien has charge of that department in the street railway service; if so, he might be able to give us some information.

MR. BENTZIEN:—We are using the Barr wheel, but I am not familiar with the matter.

MR. BENZENBERG:—I was going to ask the real cause if discovered of the peculiar accident that happened a day or two ago on a Washington St. car. The car had just turned the curve on to West Water St., when all at once the rear part of the same flattened right down and settled completely on to the rail, so that the box rested on the wheel, and when dragging the car out, I noticed that the axle was broken right straight through on both sides, just as clean a break as I have ever noticed. The car was fairly loaded, but still not so heavily as it certainly had been. It did not give way first at one end and then resultantly at the other, but both wheels gave out at the same instant. The break was just inside of the wheels.

MR. BENTZIEN:—Of course, most of these wheels have seen a great deal of service. As to the case in question, I have not heard what the cause of the accident was. I will look it up.

The question was asked whether the fracture showed large crystals, to which Mr. Benzenberg replied as follows:

I did not stop to examine, but as far as I recollect, the crystallization was quite close and even. It was smooth I hardly thought it a break. In both cases the break was just inside the wheel.

MR. SCHOLTKA:—Might it not be caused by the strain produced in going around the curve on the rigid track. Of course, on a heavily loaded car, there would be a strain on the two inside wheels, which might cause such an accident.

MR. BENZENBERG:—The car had just about rounded the curve. If break were caused asy ou suggest, it seems to me that one wheel would heve gone before the other, while there is no doubt that both wheels came out together.

MR. BENTZIEN:—It seems to me that one wheel would go before the other, but I will look up that case.

MR. SCHOLTKA:—I have made some of the chills for Mr. Barr, but

Mr. Barr could explain the operation better. I know how it is done, but do not understand what the chill is. Just before he pours the iron, he puts a jet of steam into this hollow cast, and after pouring, which is done considerably quicker than by the old process, he shuts off the steam and puts in cold water, and the chill follows, but it has always been a question in my mind whether the chill retains its true circle or not, since you first heat it and then cool it off, but he also makes a steel cast, and I have seen wheels made by this process which were within a thirty-second of being true, while we know that a wheel cast by the old process will run out at least as much as ⅛ inch, since the shrinkage on a 33 inch wheel is considerable.

Mr. Benzenberg:—I suppose that the advantage of the steel wheel is that it is homogeneous in its make up.

Mr. Goetz:—Yes. The manufacture is about as follows: (Here Mr. Goetz gave a somewhat detailed account of the manufacture of steel wheels, with general discussion) Continuing, he said: You will see that this is a rather expensive manufacture, and when they did not know how to make these wheels, you could wear out five or six iron wheels before you could get one steel wheel, but now the manufacture of steel generally is getting cheaper, and we are getting to the point when we will be able to have steel wheels. When the North Chicago Rolling Mill Co., commenced to make steel rails, they sold them at $150. per ton; today they are $31. So with tires; they sold all the way from 20 to 30 cents originally, then they sold for a long time from 5 to 6 cents per lb., now so many people have started the manufacture that you can buy them for less than 3 cents. I admit that steel wheels will have to last twice as long as iron wheels in order to be as cheap, but the matter of safety should also be considered. In Europe generally, the steel wheel is used, except in Austria, where the chilled iron wheel is used, for the reason that there they make a great deal of charcoal iron.

The question was raised what effect the presence of silica in iron would have on the chilling of same, to which Mr Goetz replied: If you get enough silica, you wont get any chill, unless you add manganese, when you will get a chill, but it makes the iron brittle. We had a large number of pig iron samples that we had chemical analysis made of very closely, and then put them in cases, and we would take samples of iron and compare same with those sections when we could not make an analysis, and in this way we could estimate very closely the chemical composition. We found that after the silica got to be 1½ per cent., the chill stopped, but could get chill again by adding manganese, but by this time a mixture is obtained that cannot be used.

Mr. Scholtka:—I understood that they put in a certain percentage of manganese to reduce the chill. I had some trouble in getting the

proper grade of softness in iron, and I consulted Mr. Barr in the matter, and he said they used a certain amount of this manganese to reduce the chill.

Mr. Goetz:—The tendency of manganese is just to the contrary. Of course, this is a rather complicated matter, as no two pieces of iron are exactly alike, and a great deal depends on the amount of carbon in your iron.

Mr. Scholtka:—As an experiment, I took two small ladles of 100 lbs. each of the same iron, and into one of them I put one-half lb. of manganese. Otherwise, I treated them both in the same way, poured both ladles at the same time, and tried to make everything as uniform as possible. In this case the manganese made the metal softer; the casting made without the manganese could not be used.

Mr. Goetz:—That result can only be possible if manganese was very low: the carbon did the work in your case. In the steel mill we add manganese to make the metal harder. If you put in 10 per cent. of manganese in steel, you cannot touch it with anything. It acts just like copper. Instead of hardening by putting in water, it softens.

The question was asked whether manganese would not have different effect on different irons, to which Mr. Goetz replied: Yes; and another thing, if you have sulphur in your iron and put in manganese, as soon as it combines with the sulphur, it rises to the top, and the manganese does not stay in the iron: you better your iron by taking out the sulphur. There are being constructed at Chicago two tanks, each tank to hold 150 tons of liquid pig iron. The object is to get a large amount of uniform iron. As it comes from the cupola, every minute you have something different. Take 20 tons of iron and melt it and put in same charge right along, and you will have different results. Put in a large charge and small charge, and you will get different iron. We had a case of a large wheel some time ago; we used three ladles and we found that the wheel was considerably harder on one side than it was on the other.

HIGHWAY CONSTRUCTION.

By William E. McClintock, Member Boston Society of Civil Engineers.

[Read February 17, 1892.]

A little over a year ago the question of highway engineering was first discussed by this society. Early in 1891 it was decided by the Government to devote an evening to the same subject during the present year.

When by vote of the Government I was requested to conduct the meeting I made up my mind that we would try and begin where we last left off and cover as little of the ground as possible twice.

Having at the last meeting gone back to the Roman roads as good examples of how long a time well constructed roads will endure, I thought that at the present meeting we had better keep to modern history and let ancient alone.

The theoretical and actual results are a good example of how the unexpected will happen in engineering.

One of the first questions that was brought to me by a superintendent of streets, was to decide what it was, in the case of some bits of rock and where it could be found, and whether in large quantities.

Before I had answered this little question I found myself away back to the Huronian or only one remove from the first stroke on the earths' very foundation and that my researches extended all the way to the post Pliocene and Psychozoic.

I have awakened in the middle of the night only to find myself trying to decide the difference between a diorite, a delorate and a diobase, or between syenite, granite and diorite.

In fact one of the most facinating studies I have ever attempted has been this one of trying to apply geology to road building although as yet I have only reached that stage where I feel that I know really nothing.

It is not my intention to inflict any amateur geology on you, but I do think that I can show you that there is a beautiful chance to get aid from the geologist.

It is my intention to speak generally of the main kinds of rocks to be found in eastern Mass., with their values as road metals and some few reasons for accepting or rejecting certain stones.

It is also my intention to show by a colored map where these stones can be found in a general way and in a measure prepare ourselves for what is in store for us if we are called to any particular locality to advise on materials.

In order to make my talk plainer I have a colored map prepared by Prof. Wm. O. Crosby of the Mass. Inst. of Technology and kindly loaned for this occasion, also some 25 or 30 specimens of rock from the same source.

LIST OF ROCKS.

I have prepared a list of the rock specimens which I have, and on this list have put the weight per cubic foot, as far as possible.

At this point it may be well to call the attention to the weight of the different rocks, and show how utterly worthless the specific gravity tests are for determining the value of road metal. You will note that slate is shown as 175 pounds to the cubic foot, or exactly half way between felsite and trap. Pure mica has a weight of 183 lbs. per cubic foot.

None of us would for a moment think of using either of these substances as road metal. Mica schist which is almost entirely made up of mica, with a slight addition of quartz, would be considered unfit for use, in fact it would not be worth quarrying.

In the remarks which I shall make on the value of different rocks, for road metal, I am guided largely by my own experience, and the experience of others, as I understand it.

In determining the value of different rocks for road metals, while we may not expect to get an exact value for each material, yet I am satisfied we can get a comparative value which would be of great use. Undoubtedly the best and most accurate comparative test would be obtained by dividing up a stretch of road or street between two cross roads or streets, into as many sections as we have materials to try, build a thoroughly even and solid foundation, and construct each section under exactly the same conditions, with the different metals. If all of this work should be done at one time and compacted in the same manner, we could, by a series of cross sections, and careful account of the number of tons of metal needed to keep the different sections in repair during a term of years, ascertain the comparative value of each metal, as each metal would have the same amount of travel, passing over it. While the above method would give us a complete comparative test of values, the values would only apply to the exact wear which would be represented by the tonnage, and the character of the traffic.

We might build a road of any kind of metal, and with a light travel made up of teams for the most part with springs, get perfect results. If now, we should turn over this same piece of road a heavy dead axe travel, we might find that disintegration would begin in a very short time, and it would be impracticable to maintain the road in a good condition. This point should be strictly born in mind in deciding a road metal.

If we were to build a city street, or a main highway connecting a populous suburban district with the city, we should select the very hardest, toughest, fine-grain metal.

As we work away from the city and the more populous suburbs it becomes a question of material and traffic, and we may be guided by the location of our metal and the cost of transportation to the work.

I shall attempt to show by the geological map, that with most towns, in the eastern part of the state at least, a little judgment in the selection of a quarry, will give us excellent road metal, without excessive cost of transportation.

A study of the map shows us certain areas as drift, or general Huronian. In these areas, we find no ledges, of any account, although there may be good material, such as is found, for example, in Chelsea, and Everett, a dyke of Diabase, or Trap which can be utilized.

We also find in these districts, and the large areas covered by gneiss, large quantities of field stone, which have been deposited by glaciers.

These field-stone furnish us with all kinds of rocks, from the hardest trap and amygdaloid to the poorest and softest description of mica schist. We can get a very fair road metal from these field-stone, if we throw out all schist, slate and sandstone.

We must necessarily get different degrees of hardness, and unequal quality, in road metals, made up of such varied rock: the tendency of such uneven qualities being to make uneven surfaces, which must be watched closely, in order to prevent complete destruction.

I will now take up the different rocks as I have them, and give a short description of their values as road metal, with the localities in which they are to be found throughout the eastern part of the state.

Undoubtedly trap rock makes the best road metal for macadamizing that can be found. Its hard, compact structure, free from large crystals makes it durable and gives a good bond between the different stones. Its shapes when broken are also favorable to good even wear and firm bond. Trap and greenstone are synonomous terms, the only difference being the green color which is imparted by the presence of chlorite.

Trap is an eruptive rock and is found forming regular, wall-like dikes. Its location may be seen by examining the map where it is colored green. Starting in Newbury at the Merrimac river back of the drift we trace trap through Newbury, Groveland, Ipswich, Boxford, easterly part; Middleton, Wenham, Hamilton, Essex, a small amount; Beverly, westerly part; Salem, Marblehead, Danvers, North Reading and Lynnfield. There is a break at this line filled by granite but the trap shows again through Wakefield, Stoneham, Woburn, Winchester, Arlington, westerly part; Lexington, easterly part; Waltham,

Lincoln, easterly part; Belmont westerly part; Weston. We also find it in smaller areas through Dedham, Medfield, Franklin, Wrentham, easterly part; Foxboro, northerly part; Sharon, northerly part; Stoughton, and Randolph.

Felsite. An eruptive rock with no separate grains or particles but not amorphous or glassy. This rock is for the most part hard and always smooth as it must be with no crystalline formation.

I have before me five specimens of this rock and an examination will show that at least four of the five pieces will make good road metal. Some of these are popularly known as porphyry and all of them have the porphyritic texture or the hard crystals encased in a matrix of fine-grained material. These rocks break into good shaped cubes and should make a good road metal.

Their location on the map is indicated by the purple color.

The areas are less than with the trap and the territory less extended.

Felsite or the part of it we call Porphyry may be found in almost all of Lynn, Saugus, and northerly part of Melrose. The same rock under the name of Felsite, Breccia, is found in the southerly part of Melrose: Wakefield about Greenwood, Medford, Needham plains, Dedham, Hyde Park and Braintree.

In my opinion this rock comes next to the trap for road metal although it is not found over so large an area.

Granite. I have before me several specimens of granite.

The Cape Ann, red granite and Quincy granite are Huronian granite and are made up of quartz, feldspar and hornblende. The feldspar of the Cape Ann specimen is of a light gray color, that of the red specimen is red while that of the Quincy is dark gray. The three are of practically the same value for road metal and break into fairly good shaped cubes. I do not think they have the same value for road metal as the previous specimens for the reason that the crystals are larger, and by receiving the shock of heavy traffic would crush as the point of resistance is so small. As the exposed crystals crush new ones are exposed which pass through the same process.

While not so durable as trap or felsite yet I should not hesitate to use these three granites if the others were not near at hand.

A study of the map shows that these granites may be found in the following places:

Newburyport, Newbury, Rowley, Ipswich, Topsfield, Hamilton, Wenham, Essex, Gloucester, Rockport, Manchester, and Beverly, Marblehead, Swampscott and Lynn, Danvers, Lynnfield, Reading, Wakefield, Saugus, Medford, Weston, Wayland, Needham, Sherbourn, Dover, Medfield, West Roxbury, Dedham, Milton, Quincy, Braintree, Randolph, Canton, Holbrook, Stoughton, Brockton, Easton, Sharon, Foxborough, Wrentham, Weymouth, Abbington, Hingham, Cohas-

sett, Scituate, South Scituate, Hanover, Marshfield, Pembroke, Duxbury, Kingston, Plympton, Easterley point of Halifax, and a small piece of Franklin.

The distribution of these granites through the above towns seems to be in such a manner that the ledges can be worked to advantage for road metal without too great a haul.

The next specimen of granite is what we shall call Montalban granite. It differs from the last by having mica substituted for hornblende and it is softer and much lighter in color. I shall not rank it among the good road metals and should not use it unless there was a great scarcity of any of the preceding rocks. It being soft the tendency is to crush and waste and repairs will have to be almost constant with any amount of traffic in order to keep a road in good condition. This kind of granite makes up the quarries on Rollstone hill in Fitchburg and is found also in the following places: Pepperell, Dracot, Chelmsford, Tyngsboro', Westford, Groton, northern part of Littleton, Harvard, Bolton, northwest corner of Berlin, southeast corner of Clinton, Boylston, Shrewsbury, Worcester, Andover and North Andover.

The areas covered by this granite are smaller and it seems to crop up in rather narrow bands as can be seen on the map.

Conglomerate. The speciman I hold now is well known in this section under the name of Roxbury pudding stone. On the map it is shown as conglomerate.

It is hard and compact and makes a fairly good road metal.

Possibly the rounded surfaces of the pebbles may tend to make it harder to compact in a road, yet on the whole I am of the opinion that it ranks certainly next to trap rock and Felsite. The pebbles that show are in the present case felsite and quartzose while the matrix seems to be made up of about every thing we can mention, but of a softer substance than the pebbies.

This rock can be found only in the near vicinity of Boston which would seem to support Dr. Holmes' theory of its formation although the geologists tell us it is a beach formation. It is shown on the map in the following places:

Brighton, Newtonville, West Newton, Lower Falls, Upper Falls, Newton Centre, Brookline, Roxbury, Dorchester, Hyde Park, Squantum, Neponsit, and in a long narrow strip through Milton and Quincy, to the Bay. Also in Weymouth and Hingham, and in two small patches at the lower end of Nantasket Beach.

Amygdaloid. I now have two specimens of volcanic rock of very hard compact make up. There is no doubt but what the different materials were thoroughly mixed before cooling and I should not hesitate in setting them down as good road metal. Amygdaloid, like the conglomerate, seems to confine itself to the vicinity of Boston and

can be found in smaller patches in the same localities as the conglomerate.

Syenite. This piece of rock somewhat resembles granite but differs from it in its make up. Syenite has no quartz. Some syenites have hornblende and others have mica, the first making hornblendic and the second micacious syenite. The specimen shown is hornblendic.

As to syenite as a road metal I cannot offer an opinion as I have not seen it used. I should say that it would bind in a very satisfactory manner. I should judge that the large crystals would tend to crush under heavy loads although whether this crushing would continue to the final destruction of the rock I can not say.

Syenite is found only in the vicinity of Salem and Marblehead at its northerly point and at the southerly point of Beverly. Baker's Island is of syenite. The question of its value is not of any importance with us as both Salem and Marblehead have great quantities of trap and Beverly has granite as before mentioned.

Sandstone. I have now three specimens of sandstone. Two of them are quartzite or made of grains of quartz combined with an abundant supply of silicious cement. They are very hard and I should say brittle. I should say that the one with coarser grain would serve us as road metal better as there would be a better bond than with the lighter colored and smooth one.

The third specimen is a carboniferous sandstone, it seems softer than the others. I cannot say what its properties are when used for road metal. I shall hope soon to ascertain more definitely on this rock.

The carboniferous sandstones cover a large tract of country through Hanover, Abbington, Pembroke, Hanson, Halifax, the Bridgewaters, Easton, Mansfield, with a comparatively narrow tongue extending northeasterly, through Franklin, Walpole, Dedham and Randolph.

In a cold climate like ours, I am of the opinion that any sandstone will absorb a large amount of water and disintegrate under the action of frost.

This quality, together with its inability to withstand any severe shock, would certainly place sandstones on the doubtful list.

Several of these towns have either granite, amygdaloid or trap but others have no ledges of any account, and it may be a question with them whether they break up the sandstone or purchase from more fortunate neighborhoods a better material. With no very heavy travel I think these rocks would give fair satisfaction and be cheaper than a better grade of rock moved any very great distance.

This is one of the districts that is on debatable ground and of which I will speak later.

Slate. I do not hesitate in throwing out all kinds of slate from our

list of available road metals. I have several specimens here which you can examine. Wherever they have been used they crush up and resolve themselves into a fine powder. Its stratification is such that under the shock of travel it separates into thin layers when it is easily crushed by the traffic and becomes fine dust or the worst kind of sticky mud which adheres to vehicles with great tenacity.

The slates cover quite a large territory, but fortunately a district that is well supplied within a reasonable distance with either granite, trap, felsite, amygdaloid or conglomerate. It is found on the map in Malden, Everett, Medford, Somerville, Arlington, Charlestown, Boston proper, South Boston, Cambridge, Belmont, Watertown, southerly part of Waltham, at Newton Corner in Auburndale, and narrow streaks of it through Newton, Brookline, Roxbury, Quincy, North Weymouth, and Hull.

Gneiss. I have two specimens of gneiss which covers quite a large area of the state. I should not use this rock if I could obtain any of the others mentioned excepting slate and perhaps sandstone.

It is a question in my mind whether the sandstone or gneiss are fit to use. I think that the gneiss is too soft and will easily crush under traffic and soon turn to mud and dust.

I should prefer to take my chances with a mixed field stone for use as road metal to using gneiss.

It is found through the territory extending from Boxford, and North Andover on the north to the Rhode Island line on the south, and lying between Reading, Wayland, Franklin, and adjoining towns on the east, and Methuen, Westford, Harvard, Worcester, and Webster on the west, also the country lying westerly of Fitchburg and Webster, for the whole width of the State, as far as our map shows.

Classing gneiss as among the very poor road metal we find a large piece of country in a predicament when they start off on road building with broken stone.

I have remaining four pieces of rock. Two of these are Huronian limestone which is very hard but only shows in a comparatively small patch in Lynnfield. It matters but little whether it is good or bad as there is plenty of good rock all about it.

The specimen of Montalban lime stone is softer and like the other is of no importance as it is only found in very small patches cropping up through the gneiss.

Mica Schist. I have now two specimens of mica schist which is utterly worthless as road metal. This rock covers quite a large territory starting at Amesbury, Haverhill, Lawrence, Lowell, Harvard, Worcester, and out of the state at Webster, with another arm starting at Townsend and extending through to Worcester.

The argillate specimen is somewhat harder than the schists but

not by any means good for road work. This extends between the schists from Worcester northerly to the New Hampshire line.

A further study of the map shows us a narrow strip starting at Burlington and extending through Lexington, Lincoln, Wayland, Framingham, Natick, Sherborne, Hollston, Medfield, Medway and Franklin which is classed in the general Huronian period or where no rocks are visible. In other words the overlying deposit is too great to see what there may be underneath.

Taking this territory into consideration with the gneiss, schist, argillate and Montalban granite we come to realising the fact that westerly of the Diorite or trap and Huronian granite we find no really good road metal and but little of any value at all.

In our discussion of last year we showed very plainly that the cost of breaking stone for road use was the smallest item in preparing it for distribution on the roads. The quarrying and moving to and from the crusher comes in for a good share of the cost of final finished work.

It is a fact which all must admit that a large quantity of rock can be broken for less per ton than smaller quantities as long as we can keep the large plant at work with no waits or loss of time.

The cost of transportation by rail is not excessive over distances of many miles. With the cost of breaking and first handling to the minimum: the saving of more than one handling or storing for more than a few hours or days at most, and the performing work under competent direction would seem to indicate that these districts badly located for road metal will have to be supplied from large plants placed at such points as will reduce the cost as above referred to.

The foundation course where such a course is needed can as a rule be taken from the native stock leaving the wearing course alone to be transported from a distance. This seems to me the best way out of the difficulty and the way that will develop itself as occasion requires.

The day is fast passing when all kinds of rock are to be dumped into street work. Towns are now and will soon find even to greater extent that bad rock is a waste of money and the results are such as will kill all efforts towards getting this kind of work continued.

Brains must be put in at the start or when the crusher is put in place or the question of the materials are to be selected.

The day is also coming when we shall not see a crusher set up in a slate ledge when a trap dike makes up within a few hundred feet of it.

The day is coming when we shall not have the objection that granite is selected because it weighs less to the yard than trap.

What I have said so far is open to discussion on certain points and I trust the disscussion will come, only don't expect me to answer offhand many questions on geology.

Having discussed the general location and value of different road

metals, found in the eastern part of the state, I will now answer a question that has often been asked, and that is, the weight of a cubic yard of broken stone. We can take the specific gravity and weight of a cubic foot, and multiply by twenty-seven, less the percentage of voids and we ought to get good results. If, for example, we take trap-rock, and call its weight per cubic foot 180.7 pounds, we find the weight of a cubic yard to be 4,879 pounds. If we say that the voids are 47 per cent., we find that a cubic yard of broken stone (trap) weighs twenty-five hundred and eighty-six (2586) pounds.

In order to test the matter thoroughly, I have carefully measured and weighed several hundred tons of trap rock, as it comes from the Salem plant of the Mass. Broken Stone Company, with the following results:

The stone as it comes from the crusher passes by elevator into a revolving screen separating into three sizes, with the tailings passing from the end. Diameter of screen 40 inches: length of screen 10 feet: revolutions 19 per minute.

The smallest screen has a mesh of ½ inch, section 3½ feet long.

The second size has a mesh of 1½ inches, section 3 ft. long.

The third size has a mesh of 3 inches, section 3 ft. long.

For convenience I shall number the sizes 1 - 2 - 3, the finest being 1.

No. 1 measure was made by using a bin of about 29⅓ cu. yds. weighing 76,430 lbs. when filled, or 2,605 lbs. to the cu. yd.

A trial was made with No. 1 by using a zinc lined box holding practically a cu. yd. The dust or No. 1 was weighed after packing wet and a second sample of dry was weighed.

Weight of No. 1 wet was 2,480 lbs. to cu. yd.

Weight of No. 1 dry was 2,690 lbs. for cu. yd.

This last simply shows that the dry dust packs closer than when wet by about 200 lbs. to the cu. yd.

No. 2 measure was made by using a bin of 89.832 cu. yds., weighing 217,495 lbs. when filled or 2423.3 lbs. per cu. yard.

No. 3 trial was made by measuring and weighing six cars and also by measuring and weighing a bin containing 89.655 cu. yds., weighing 226,130 lbs. when filled, or 2,522 lbs. to the cu. yard.

The six cars measured 45.105 cu. yds. weighing 114,150 lbs. or 2,531 lbs. to the cu. yard.

The tailings were all carried back to the crusher and broken up.

To find the proportion of the No 1, No. 2 and No 3, I measured 18.882 cu. yds. after breaking and find of

No. 1—13.24 per cent.

No. 2—23.89 per cent.

No. 3—62.87 per cent.

The above figures I find very useful in estimating the amount of stone needed for any piece of work.

It must be remembered however, that in placing stone on a street there is considerable shrinkage owing to heavy rolling and compacting, and this amounts at times to from 15 to 20 per cent.

What I have said applies wholly to macadam roads. We shall hear soon from what has been done in Boston during the past year as to paving with some interesting experiments on the power of different materials to stand abrasion. We shall also expect to learn some facts about macadam work, brick and asphalt paving and other points that are of value and the result of actual work.

RECENT CONTRIBUTIONS.

If any of the members of the Boston Society wish to know what others are saying and doing on this subject of road making, I think they will find a great deal of valuable information in the two books which I have before me,—"Essays on Roads and Maintenance and Road laws," and, 'Streets and Highways in Foreign Countries."

The first is a series of papers written for and published by the University of Pennsylvania.

These essays must be of value, inasmuch as they give the views of different men approaching the subject from different standpoints and incorporating the best results of actual work, and theory as they understand it. These papers ought to give the best theoretical road and the manner of construction and maintenance.

The second book is the result of examinations made by the different U. S. Consuls in foreign lands and gives an abstract of what other nations are doing.

For example it is interesting for us to compare China with our own country.

It is interesting to know that strictly speaking there are few roads and but little need of them as the work is performed by Coolies or horses, most of the freight transportation being on the the backs of Coolies. The Chinese have yet to take lessons from the old Roman Emperors in the matter of building military roads as most of their fighting is done by cavalry with no heavy ordnance.

I think the following description from Ningpo will be of interest.

"The roads in the country are mere paths being only about four feet wide. Now and then a square stone about 4 feet high and perhaps a foot square is seen close to the highway; the traveler weary with his load, places his back to this stone and lets his load down onto the stone and rests awhile and when he is ready to renew his journey he does not have to pick up his load from the ground, but simply from this resting place. There is not a wheeled vehicle of any kind in this vast district of nearly 40,000 sq. miles."

One interesting fact that may be of service in forming an opinion as to the reasons of the old Roman roads lasting is gleaned from the report on Palestine, viz:—

"The principal pavements made in Palestine are in the city of Jerusalem, and it is only within recent years that they have been constructed with anything like modern requirements. The superior and massive Roman pavements, over 2,000 years old, and still in fair preservation, are not taken into consideration. They are indeed, hidden from sight and use many feet beneath the rubbish of the city."

The most natural question right here would be, where is the street cleaning department? Or:—if Roman roads will last 2,000 years without cleaning why is it not economy to leave our streets uncleaned?

Leaving comment aside I think that there is a great deal to learn from this report and that it will repay anyone the time required to read it.

LEGISLATION.

A civil engineer should not be a politician, at the same time he should not neglect a plain duty because it requires politicians to carry out certain schemes which in his opinion are public benefits.

Last year the state legislature had before them the important question of establishing a state highway commission to consist of three men who should attend to all main highways or state highways and build and maintain the same in a scientific and economical manner. According to this bill the state was to appropriate $10,000,000 with which to purchase breakers, steam roller, etc., and either build or furnish the plant to towns to build highways, allowing all towns a certain rebate on account of work done in accordance with the plans laid down by state commission.

While there may have been defects in the bill as reported there is no doubt in my mind that the only way to obtain continuous highways throughout the state is by some such law, or at least by concerted action with a power to direct, at the head.

I do not intend to go over this ground, as it involves the loss of power and energy on poor roads as against good roads, and that point has been covered many times before.

It would have been impossible for the Roman Emperors to have held their sway over such immense countries without a thorough system or roads and it is estimated that there were built some 20,000 miles of roads, which we should call good at this time. With the neglect of maintaining these highways the Roman Empire began to fall; whether this was one of the causes or simply an indication of other causes is not for me to say.

There is no doubt in the mind of anyone present but what most of the rapid greatness of this country is due to railroads.

With so vast a territory as we have it would have taken hundreds of years to have reached our present degree of prosperity by any other means. The great framework is up and it now remains for us to complete the superstructure. It remains for us to fill in the intervening spaces of the railroads with first class highways.

STREET WORK IN BOSTON, AS APPLIED TO BRICK PAVEMENTS, FILLING JOINTS OF GRANITE PAVEMENTS, STREET WATERING AND STREET CLEANING.

BY HENRY B. WOOD, MEMBER BOSTON SOCIETY OF CIVIL ENGINEERS.

[Read February 17, 1892.]

BRICK PAVEMENTS.

Much has been said of late in praise of vitrified brick as material for paving.

Like all new inventions statements in regard to it seem to be largely exaggerated, both as to the amount now in use and also as to the years of test to which, it is alleged to have been subjected.

Believing that it was worthy of trial, the City of Boston has, during the present season, laid three streets in brick of different makes.

These streets have a moderate degree of teaming thereon, sufficiently heavy to be good subjects for a test.

Oswego street is laid with brick manufactured in Rhode Island, Seneca street is laid in Keromite brick made in Pennsylvania. Genessee street is also laid with the same.

In addition to results obtained on these three streets, it was thought best to inquire into the experience in some of our western cities where, on account of their location, in close proximity to excellent brick yards, the use of such a pavement would, more naturally, be resorted to for the sake of saving the freight.

It is found that a brick pavement is smooth, noiseless and easy to clean, that from its shape it can be laid with narrow joints tightly filled with cement grout, thus making a perfectly tight surface; it remains to prove that that surface is not too brittle to chip, and not too soft to wear away rapidly, and not too porous to absorb too large a per cent. of moisture.

Our experience, so far, seems to show that there is not only a great difference in the quality of bricks from the different manufactories, but there is an enormous difference in the bricks made in the same yard, so that until there can be some guarantee that bricks can be vitrified to a desired point, and uniformly so, it is useless to urge a brick pavement for universal use.

It would seem that if the attention of experts is directed to this matter so as to produce a brick that shall combine toughness, elasticity, homogeneity, resistance to abrasion, heat, water or frost, a brick may yet be produced which shall be welcomed as the panacea sought for.

Reference has been made in Engineering Journals, to its use in Holland and Belgium for over a century, the truth of the matter is, that the pavements in both these places have been covered from inches to feet deep with street dirt and the wear, consequently, has not come on the surface of the brick.

They have been used, however, in Staffordshire, England, for upwards of fifty years, and in London for paving the approaches to freight depots, where the traffic and vehicles are exceptionally heavy.

In Columbus the yards at the freight depots and the approaches to the Baltimore and Ohio R. R., are paved with the same material.

In Chicago the yards at the freight depots and the approaches of the Chicago, Burlington & Quincy R. R., are laid in Galesburg brick.

Cleveland is said to have had 45 miles, Philadelphia 26 miles, largely in out-lying districts.

It is also alleged to be in common use in Wheeling, Johnstown, Alleghany City, Omaha, Indianapolis, York, and Baltimore.

But so far as can be ascertained, in most of these cities, they have only begun to lay this form of pavement, and that in the way of experiment.

It is learned upon close inquiry that Pittsburg has only two or three streets paved with brick, one a 30 foot roadway, of medium heavy traffic, four years laid, and found not quite equal to the test.

Alleghany City has found that with heavy traffic it has to be removed after six years service, and recommends it only where traffic is light.

In Bloomington, where the first pavement was laid fourteen or fifteen years ago, it is claimed that the street is now in good condition, the test here is not considered a severe one, as less than 1000 vehicles pass over it daily.

The cost has seemed to vary from \$1.50 a square yard to \$2.75 a yard. In Boston, Seneca St. has cost \$2.75 a square yard; and if laid on a concrete base it would cost \$3.65. Oswego St. cost \$2.40 a square yard.

It is seen at once that freight rates have a good deal to do in regulating the style of pavement selected for a given locality.

Tests made of Ohio brick show that they absorb less than 3% of water and of West Virginia brick a still less amount. About the only form of artificial tests applied are: 1st. The absorption test, either by volume, as found by the absormeter, or by weight, and 2nd. the rattler

test which consists of a revolving cylinder in which is placed the brick with one or two hundred weight of foundry shot (nuggets broken off of castings) and the abrasion obtained from the loss of weight, after a certain number of hours of revolutions.

The following tables will show the varying results of testing the standard bricks now on the market:—

RESISTANCE OF PAVING BRICK, STONE AND ASPHALT TO ABRASION AND IMPACT. MECHANICAL TESTS MADE WITH A FOUNDRY "RATTLER," BOSTON.

Ref. No.	Loss in Per Cent. of the Original Weight During			Total Loss.	Absorptive Power, in Per Cents. of the volume of the Dry Brick.
	1st Half Hour.	2nd Half Hour.	3rd Half Hour.		
	Granite and Asphalt.				
1	0.88	0.46	0.37	1.71	0.8
2	3.63	2.57	2.42	8.62	
	Paving Brick.				
3	1.43	0.96	0.48	2.87	
4	2.83	1.15	0.99	4.97	
5	1.51	0 71	0.55	2.77	2.2
6	0.84	0.30	0.30	1.44	
7	0.68	0.49	0.37	1.54	1.5
8	0.62	0.49	0.37	1.48	2 0
9	0.62	0.56	0.49	1.67	1.5
10	2.81	1.76	1.22	5.79	3.0
11	1.98	1.86	1.68	5.52	6.0
12	1.03	0.54	0.36	1.93	6.0
13	0.90	0.41	0.25	1.56	
14	4.32	3.66	4.24	12.22	23.3
15	1.60	0.97	0.62	3.19	10.0
16	2.19	1.83	1.60	5.62	14.0
17	1.72	1.00	0.55	3.27	
18	1.66	0.90	0.67	3.23	

	Addenda.		Absorptive Power, in Per Cents. of the Weight of the Dry Brick.
7			0.17
8			0.19

Three Samples of the Brick numbered 7, 8, 9, were tested at the Watertown Arsenal, as to their Transverse Strength, with the following results:

			Modulus of Rupture, in Lbs. per Square Inch.
A			1925
B			2072
C			1700

THE MCLAGON FOUNDRY CO., BRICK MACHINE DEPARTMENT.
RECORD OF TEST OF PAVING MATERIALS.

Name.	Weight Before Test.		Weight after 4 Hours Tumbling.		Actual Loss of Weight.		% of Loss From Abrasion.	Weight After 15 Hrs. Immersion.		Weight of Water Absorbed.		% of Absorption.
	Lbs.	Oz.	Lbs.	Oz.	Lbs.	Oz.		Lbs	Oz.	Lbs.	Oz.	
1. Granite..........	4	9½	4	2		7½	10.2	4	4		2	03.
2. Vit. Brick......	4	12	4	3		9	11.84	4	4		1	01.49
3. Vit. Brick.......	4	12	4	0		12	15.78	4	0			
4. Vit. Brick.......	7	1	6	0	1	7	15.04	6	2		2	02.08
5. Vit. Clay Brick.	7	2	5	4	1	14	26.31	5	8		4	04.76
6. Vit. Fire Clay Brick.........	6	6	3	8	2	14	45.09	3	13½		5½	09.82
7. Sewer Brick...	2	1	0	13	1	4	60.60	0	14½		1½	11.53
8. Sewer...........	4	6	1	14	2	8	57.14	2	1		3	10.
Broken Pig Iron Used for Tumbling in Barrels with above Brick and Stone..............	299		266½		32½		10.87%					

TENNESSEE PAVING BRICK CO.
THE FOLLOWING IS THE RESULT OF COMPRESSION TESTS OF PAVING BRICK MADE AT ROBINS, TENN.

Sample.	Dimensions.			Total Crushing.	Crushing.
	Breadth.	Length.	Depth.	Strength in Lbs.	Strength per 1 Sq. In.
No. 1......	1.78	1.88	1.88	39,090	11,681 lbs.
No. 2......	1.86	1.86	1.86	37,300	10,811 "
No. 3	1.86	1.82	1.90	38,750	11,445 "
No. 4......	1.88	1.88	1.88	40,250	11,387 "
No. 5......	1.87	1.90	1.83	39,350	11,075 "
No. 6......	1.79	1.86	1.86	38,000	11,413 "
				Average.	11,303

Specific Gravity 2.21.

PROF. O. H. LANDRETH, C. E., A. J. L. Dyer,
Vanderbilt University, Nashville, Tenn.

PAVING BRICK.
COMPRESSED SURFACES FACED WITH PLASTER-OF-PARIS.

Ref. Mark.	Dimensions.			Section of Area. Per 1 Sq. Inch.	First Crack, Lbs.	Ultimate Strength.	
	Height.	Compress Surface.				Total Lbs.	Lbs. Per Sq. Inch.
B	2.12	3.68	7.48	27.53	91,000	800,000	29,060
P	2.05	3.68	7.62	28.04	93,400	800,000	28,530

Bricks sustained the maximum power of the testing machine.
They were broken by numerous cracks, but the highest loss they were capable of sustaining was not reached.

Correct,
J. E. HOWARD. W. S. MARYE,
Lieut of Ordnance Dep't. U. S. A. Commanding.

TEST MADE AT THE UNITED STATES ARSENAL, WATERTOWN, MASS., JUNE 5, 1891, ON TWO FIVE-INCH BLOCKS OF MOLDED GRANITE MADE BY HAND IN PLASTER MOULDS, AND TWO STANDARD SIZE BRICKS MADE ON A CARNELL BRICK PRESS.

Ref. No.	Dimensions.			Sectional Area. Cu. Inches.	First Crack, Lbs.	Ultimate Strength.	
	Height. Inches.	Compress Surface. Inches.				Total Lbs.	Lbs. Per Cubic Inch.
1 Bl'k.	4.79	5.13	5.17	26.52	176,000	333,800	12,590
2 Bl'k.	5.00	5.05	5.07	25.60	192 000	226,900	8,860
3 Br'k.	2.30	4.20	8.28	34.78	118,000	377,000	10,840
4 Br'k.	2.28	4.16	8.28	34.44	268,000	501,400	14,560

BRICK TESTS IN BUFFALO.

Number.		Absorption.	Loss in Rattler.
1	New York.		19% to 21%
2	New York, Yellow,	1.3%	5 to 12
3	Freeman.	2.2	27%
4		1.8	16.2
5		2.2	17.5
6	Penn.	3.6	43.2
7		3.6	23.2
8		1.8	26.7
9		2.2	28.8

From these tests it would appear that the Park brick stands at the head of the list, followed closely by the John Porter brick.

The Syracuse brick shows great compressive strength and is claimed to be a closer resemblance to the brick that are used abroad.

A contract for paving two miles of street was executed during the past season in Syracuse, N. Y. The two samples which we had for testing, however, showed wide extremes, one of them absorbing 6%, and the other 23% of water, while the loss by abrasion of the first was 1.56 parts, and the other 12.22 parts.

The samples tested in Buffalo showed 1.3% absorption and a loss of from 5 to 21% in the rattler.

Of course it would be unsafe to pave a street with bricks showing such marked variations.

A brick made in Galesburg, Ill., by the Purington Brick Company is said to have specially good qualities for paving purposes.

We have had no tests of this brick and as it has only been laid in small cities of light traffic, judgment cannot be passed upon it.

A few years wear around the freight yards of the Chicago, Burlington and Quincy R. R. will show its merits or defects.

In general we may conclude that brick paving may take high rank just as soon as companies shall produce a brick that shall combine all the qualities required to give life to the pavement, being uniform as to vitrification and size, and at a price that shall keep it within the demands for paving streets of moderate cost.

Chicago has invented a new form of pavement called the Chicago Steel Wood Pavement.

It is made as follows: "The soil of the street is graded and thoroughly settled by rolling or ramming and then covered evenly with from two to three inches of fine sand, steel plates of a thickness and strength to stand a tensile strain of 50,000 pounds to the square inch, is laid from curb to curb across the street in ten foot lengths, with flanges or ribs on either side to a height of one and three-eights inches, suitable holes are provided for pinning the flanges together, and the bottoms are perforated for drainage."

This may properly be called a steel cover to the street.

For surfacing, a Southern pine block 9×4×6 is laid by grooving every other block a sufficient height and width to straddle a plate rib, thus closing securely the rib joint and holding the pins immovable.

No openings are left between the seams to accumulate dirt, swellings being provided for on the sides by leaving a narrow seam next to the curb filled with clay.

The advantage of this inter-locking is claimed to distribute the pressure over a larger surface, so that it shall not come on single blocks.

It is claimed to be the cheapest and the best, and offers great ease of traction.

As we are opposed to the use of wood for sanitary reasons, we should not be inclined to think favorably of this form of pavement for a city like Boston. The inventors deserve credit, however, for their enterprise, and no doubt the peculiar advantages of their invention will meet with approval in cities where wooden pavements are used.

Specifications for Granite Block Paving, Gravel Foundation With Pitch Joints.

The following method of filling the joints has been found successful in the City of Boston during the season of 1891.

Each course of blocks must be of uniform width and depth, and laid with joints not more than $\frac{3}{4}$ in. in width. The longitudinal joints must be broken by a lap of at least two inches and all such joints shall be close as possible.

After the blocks are laid they are covered with clean, fine, hot, dry, screened gravel or pebbles, said gravel or pebbles to consist of such pebbles as in screening gravel would pass through a $\frac{3}{4}$ in. mesh screen, and would not pass through a $\frac{3}{8}$ in. mesh screen. What passes through the $\frac{3}{8}$ in. screen can be used in the bed. The pebbles when screened must be perfectly dry, so that they will screen clean. The pebbles are swept into all the joints until they become filled therewith to within one inch of the top: the blocks are then to be thoroughly rammed to a firm unyielding bed with a uniform surface, to conform to the grade and crown of the street.

After the blocks are thoroughly rammed, there is then to be poured into the joints a paving-cement, known as and called road-pitch, and which is obtained by the direct distillation of coal tar, and must be poured at the rate of four gallons to the square yard of paving, and at a temperature of 300 degrees Fahrenheit, until the sand beneath and the pebbles between the blocks will not absorb any more, and the joints are filled flush. Then the upper surface of the paving to be flushed all over with the road pitch to the depth of $\frac{1}{4}$ in., and this covered with a light coat of dry, hot sand, of sufficient quantity to absorb the pitch, and make the top surface hard and at the same time elastic and firm. This flushing of the surface is omitted in most cases.

A great deal is said throughout the West in praise of a new interstitial filling which is called Murphy's Grout Filling, now in use in Columbus, Ohio, for six years, adapted to any kind of block paving, stone, brick or wood.

It consists of a hard cement grout of patented proportions.

It is designed to take the place of coal tar, being 40 per cent. cheaper in cost, and would do away with the offensive odors arising from the tar kettles. If it proves tenacious and not brittle, it may find place.

STREET CLEANING.

Much public attention has, of late, been called to the subject of street cleaning in all of our large cities.

It having been found to have so large an influence on the health and mortality of a community, a mere occasional attempt to clear up

what street litter we cannot climb over is not sufficient, indeed the pavement must now be swept so clean that it is passable at any point for the pedestrian.

The cleaner it is swept, the more wear it gets on its surface.

The sweeping in itself digs into the joints and wears the surface considerably. But the public health is worth more than the paving stones. Modern hygiene calls for constant attention to the immediate removal of all kinds of street refuse from public highways and places, before fermentation takes place, or disease laden gases or dust particles emanating therefrom can be disseminated.

Cities all over the country are finding this to be a most serious problem, and are yearly increasing their facilities for handling their waste products to the least discomfiture of their inhabitants.

Statistics are not wanting to prove that the death rate per 1000 is perceptibly diminished or increased according as this subject receives proper attention or is neglected.

Boston has not been behind her sister cities in this regard.

Having increased her force, and directed her efforts continuously to the matter, a change for the better has been welcomed by the whole community.

The forth-coming report of the Street Department for the past year will show that we have spent about $215,000 for the entire work of street cleaning, not including the removal of ashes and garbage.

The City has been divided into nine new districts in which the amount of work is equalized as much as possible by taking into account the square yards of pavement, and the necessity of its frequent sweeping.

We have cleaned 7273.24 miles of streets at an average cost of $20 per mile, and have removed over 77,000 loads of street dirt. The exact cost including supervision has been $18.49 per mile, and exclusive of supervision $16.74 per mile.

The entire force of men employed has been about 300.

Some streets have been swept every day, in sweeping weather, some three times a week, and some twice a week.

The assignment of work for each day has been so made, that the computed area covered per week has figured up to an even amount or about 590,000 square yards per week to a district.

A good working gang for a paved district is as follows:—

One Foreman, one Sub-Foreman, two sweeping-machine drivers, two water-cart drivers, sixteen sweepers, six teamsters, six helpers, one dump inspector, allowing a trifle over one sweeper to a mile of gutter stroke.

Such a force costs about $23,000 for a full year.

GUTTER SCRAPING.

From the daily foremans returns for a single week in the springtime, at the first cleaning season, the following data was gathered on the cost of gutter scraping on the average macadamized road:—

DISTRICT FOUR. BRIGHTON.

Cost per linear foot	\$ 0.0124
Cost per 1000 linear feet	12.468
Cost per mile	65.83
Cost per single load dirt removed	.4745

It this district five double and eleven single teams belonging to the city were estimated at \$5 and \$2.50 respectively: the hired teams at the usual prices \$6 and \$3 per day respectively.

DISTRICT FIVE. WEST ROXBURY.

Cost per linear foot	\$ 0.0113
Cost per 1000 linear foot	13.655
Cost per single load	0.7421
Cost per mile	59.66

DISTRICT SEVEN. ROXBURY.

Cost per linear foot	\$ 0.01365
Cost per 1000 linear feet	13.655
Cost per single load	0.0686
Cost per mile	72.10
Average cost per mile	65.86
Average cost per single load removed	.63

PUSH CART PATROL.

The introduction of the push cart patrol system as an important adjunct to the regular street sweeping force has found approval in the tidy appearance of our business thoroughfares.

It is astonishing to note the rapid collection of newspapers, paper bags, sticks, fruit skins, odds and ends of all kinds in addition to the regular street dirt that is constantly being scattered upon the surface of a street filled with teams and people.

It is found that even after a street has been once thoroughly swept, in less than two hours time the sweeping off of the sidewalks and the throwing away of waste material into the street will so disfigure its surface, that it would appear as though the street cleaning force had neglected it in its daily rounds.

The push cart obviates this difficulty as it collects and removes continually throughout the day.

It consists of a two wheel truck on which is suspended an oak barrel the iron frame work, including the axle, is made of curved iron to conform to the contour of the barrel, on this is swung a wooden barrel by means of a couple of hooks on each side which fit into rings on the truck.

Each truck is furnished with two barrels, one of which is left standing by the road side for use as soon as the other barrel is filled. A patrol cart making periodical trips through the district, empties these barrels as fast as they are filled.

They are only in use in the portion of the city lying between the northern and southern depots, and have done good work throughout the year. The first cost of each cart is twenty-seven dollars.

The Flannigan odorless dumping cart has been found very useful for very wet material. It has the advantage of other carts in that its lids and covers are fitted perfectly tight, so that it is properly called odorless, it will not leak, and when it has arrived at the dump, its driver, by a movement of the lever arm, can alone instantly dump his load and move away without loss of time.

These carts are made of iron and are thoroughly durable; their capacity is 50 cubic feet.

Other open *iron* carts have been found preferable to the old style wooden carts with loose tail-boards and side-boards.

Too much attention cannot be given to the tires of all carts used for hauling heavy loads, that their width shall be, at least, three inches, if we do not wish to cut up our fine maçadam roads with narrow tires made convex in shape, so that the weight of a given load is concentrated on a surface much less in width than the tire itself.

STREET WATERING.

With fifty-five carts hired by the day and six carts owned by the city, we have watered 151.86 miles at an average cost of $332 per mile.

This represents an area of about 2,000,000 square yards.

The streets thus watered have been for the most part in the outlying districts, and represent the cheapest streets that we have to water.

Each cart in this class covers from two to four miles, and is paid six dollars a day, the city furnishing the water.

The rest of the city has been watered by contract requiring ninety-one carts and covering 131 miles, or about 2,692,000 square yards.

This work consisted of three kinds, 1st.,—Work done at the city's expense, 2nd.—Work done at partial compensation of the city. 3rd. Work done at the expense of the abuttors. As the amount collected of the abuttors is not known it would be impossible to state the whole cost of this work.

Work at the city's expense has been paid at the average rate of $120 per month per cart covering a route of 27,000 to 30,000 linear feet daily.

The total expense of the city has been $97,620.09 and the total number of miles watered has been 282.93 miles for a period of about seven months.

There seems to be much diversity of opinion as to the actual cost of street watering.

The following general data is given for information:—

Cost at Arnold Arboretum in 1887, $789. per mile, exclusive of water. Cost at Franklin Park in 1890, $496 per mile, 35 feet roadway. Cost at Brookline, $100 per month for 9,000 linear feet, watered three times daily except Sundays. Cost at Rochester, N. Y., $781 per mile. Cost at Somerville about $780 per mile. Here abuttors contribute seven cents per front foot of land and the city pays the rest.

Cost at Salem, $360 per mile for five months. Here the abuttors are assessed about two cents per running front, and the city counts that as half the expense.

Cost at St. Louis, from $336 to $450 per mile eight months.

Here the watering is entirely under municipal control.

The water is free, and the cost outside of administration is assessed on the abuttors at rates varying from three to nine cents per front foot.

The city is divided into 43 sprinkling districts averaging about ten miles each and each district is let out by contract.

This division classifies the streets according to width and pavement, and a contractor can figure his price from the length or square yards in his sprinkling district.

The cost in Boston may vary from $300 per mile to $1,500, but the only correct way in which to estimate the same is to divide the streets into classes of certain defined widths, and so separate a given district in one, two, or three spread streets.

Knowing that a cart can cover about 5.5 miles of single spread in a day, as soon as it is decided how many times per day a given street should be watered, a proper estimate can be made.

There can be no shadow of doubt but that the dust is better laid by the use of salt water instead of fresh.

The action of salt water seems to be to form a sort of crust surface, hard and flat, which holds for a long time.

A macadamized street thus watered will require but half the attention than if sprinkled with fresh water.

There is no doubt, however, as to the feasibility of using salt water on asphalt pavement, as the action of brine, urine, naphtha, or any substance acid or oilly in its nature seems to eat into the asphalt and cause it soon to break away.

Asphalt pavement should be thoroughly cleaned, flushed and squilgeed, then followed by a very light sprinkling through the day, with fresh water.

It would be to the advantage of the city to provide salt water

tanks with the proper pumping apparatus, so that the salt water could be procured easily and at a minimum expense.

The style of sprinkling carts adopted should receive careful attention to see that it is provided with no less than three inch tires, and its carrying tank should contain not less than 1,000 where salt water is used, nor less than 600 gallons where fresh water is used.

Sprinklers should be so arranged that the spray of water can be readily stopped by the driver, on either side, and the width of spread regulated at will, being never less than 18 feet, and the valves of the sprinklers should be tight.

Studebacher and Potter Rotary are good forms.

REMARKS ON WORK OF THE PAVING DIVISION OF BOSTON.

By Charles R. Cutter, Member Boston Society of Civil Engineers.

The total mileage of streets in Boston under the care of the Paving Division is $427^{65}/_{100}$ miles. The total amount of road-bed cared for is 7,865,896 sq. yds., and of sidewalk 3,921,965 sq. yds., or a total of 11,787,861 sq. yds., of surface to maintain. To do this work the Division employed 776 men on its regular force. The city is divided into ten Sections, each section in charge of a foreman who has the care of the streets, under the direction of the Deputy Superintendent. He has also the charge of the Stables, Crushing plants and all other paraphernalia, that is used in the work, and must make daily returns of all the work done and material bought.

All defects in the public streets are reported to the central office by the Police, and notices are sent to the different Foremen for repairs on the same.

Besides the building and repairing of streets, the Division also has the numbering of houses on all public streets, the placing of signs thereon and the issuing of all permits for the opening of streets.

The number of permits issued for openings by this Division last year (1891) was 18,000, all of which have to be inspected, and a record kept of them. The number of notices of defects and of those issued for other purposes was 17,000.

This Division owns eight crushing plants for the manufacture of macadam for road purposes, situated in the outlying districts. These plants are run the greater part of the year, in the winter, the stock being piled up for use in the summer. Stone is furnished to the crushers by contract in the summer months, and the city men work the ledges in the winter. This Division also uses eight Steam Rollers.

The horses and carts are hired at the rate of $3. for single carts and $6. for double, per day.

The paving for large amounts outside of patching is done by contract. The new work of this Division has embraced four different classes of pavement, first the granite block, which is mostly of Cape Ann or Quincy Granite, is laid under rigid specifications, the chief features of which are the concrete base and the filling of joints with hot pitch and pebbles: second, the Sheet Asphalt paving which consists of Trinidad Sheet Asphalt and islaid under the usual specifications by the Barber Asphalt Paving Co; third, we have used this year in the way of noiseless pavement the Hastings Asphalt block, and fourth, we have also paved a number of streets with Brick paving, but as this paving has not been in place a year, we cannot pass any judgment on it.

The macadam streets of which we have some 203½ miles covering a roadway of 3,706,825 sq. yds., vary all the from the thin veneer called American macadam to the heavy Telford base. The cost of this work is all the way from 75 cents to $2. a sq. yard. The first price for what is known as the American macadam, where the regular macadam is spread over the road and rolled with a Steam Roller, and the last price is for the heavy Telford Road. Our macadam roads are built with clean screened stone, so as to make the wearing surface uniform. Where we use a Telford base, the stones are placed upright by hand with the largest ends down and then the tops are wedged and sledged by heavy hammers, making a firm base, broken stone is then spread over this base and rolled. The surface of the road-way is covered with stone dust, wet and rolled with heavy Rollers, until the surface becomes compact enough to shed the water that is placed upon it.

The average crown used for macadam roads is ½ inch to the foot, this crown is used for Streets that do not exceed a rise of 4 feet in a 100; where the grade is steeper than this, we increase the height of the cross section.

In building macadam roads the most important thing to be considered is, that the bed of the road shall be solid and have good drainage, it being impossible to make a road stand unless there is good drainage and the surface of the road must be crowned enough to shed the water into the gutters. In surfacing a road the harder the surface, the less crown is needed. The standard of this Division for the crowning of the different kinds of streets is as follows:

Asphalt..................................	.¼ inch to the foot.
Block Paving..............................	.⅜ " " " "
Macadam...................................	.½ " " " "

Gravel Roads we crown as much as possible.

This Division also has charge of the Street Watering for which $100,000 was appropriated. The estimated cost of watering the entire city is $250,000 per year or at an average cost of $600 per mile.

The clearing of snow from the public streets and the shoveling of snow from sidewalks around public grounds and buildings are also in charge of this Division.

BOSTON PARK ROADS.

Remarks by Edward W. Howe, Member Boston Society of Civil Engineers.

I have been asked to say something as to the cost of maintenance of the Boston park roads. The roads on the Back Bay, are built on filled land, the filling being loose gravel. They are made with a covering of eight inches of broken stone. This broken stone is run over a two and a half inch screen, below which is a $\frac{3}{4}$ inch screen and below the latter a $\frac{1}{2}$ inch screen; the tailings are put at the bottom and the finer material at the top, the screenings being used for the surface. The roadway is forty feet wide including gutters.

At Franklin Park, where there is natural ground to work upon, and the subsoil is clay or clayey gravel, we have built a Telford road: there are nine inches of ballast and three inches of broken stone, screenings being used for surfacing, with a small amount of clay. The walks are of broken stone five inches thick.

The following table gives the cost of maintenance of the roads at these two parks during the year 1891.

The table needs a little explanation. It shows the area of the drives and walks, and the length in miles at each park. The cost of maintenance is divided into cleaning the drives and walks, which at Franklin Park includes a great deal of such work as trimming the grass borders, etc. The grass ground on either side of the walks requires considerable labor to keep it in shape. It is not properly road maintenance perhaps, but we find it very difficult to separate it. Then there is watering of the drives. I have separated the cost of the water, for notwithstanding the city furnishes the water the department has to pay for it. The cleaning amounts to $536 a mile at the Back Bay and $781 at Franklin park. The difference is principally due to keeping the borders of the walks in shape. At the Back Bay there is no grass ground, except a little which is cut by lawn mowers generally. The walk at the Back Bay, which borders the drive has not been built, except for a short distance. It comes next to the houses or the property line, and the construction has been deferred until the adjoin ng

BOSTON PARK DEPARTMENT.

COST OF MAINTENANCE OF DRIVES AND WALKS.

	BACK BAY FENS.			FRANKLIN PARK.		
		Cost per mile.	Cost per sq. yd.		Cost per mile.	Cost per sq. yd.
Area of Drives, sq. yds.	64,000			85,700		
Length of Drives, miles.	2.5			4.63		
Area of Walks, sq. yds.	23,400			13,500		
Length of Walks, miles	2.3			6.2		
Cleaning Drives and Walks and trimming grass borders.		$ 536.24	$0.021		$ 781.25	$0.042
Watering Drives, Water.		162.30	0.027		103.57	0.021
Watering Drives, Labor and Teaming.		524.28			396.31	
Repairs of Drives and Walks.		352.07	0.014		200.72	0.011
Cleaning Catchbasins.		54.45			31.51	
Removal of snow.		120.83			6.12	
Tools and repairs of same.		43.67			50.60	
Totals.		$1793.84	$0.07		$1507.11	$0.085

Length and Areas of Walks not used in calculating cost per mile and sq. yd.
If these areas are used the cost is $0.051 per sq. yd. for Back Bay Fens.
" " " $0.056 " " " Franklin Park.

land has been built upon: so that we have a comparatively small walk surface there to maintain at present.

The watering is very nearly the same. The drives at the Back Bay are wider than those at Franklin Park, so it should make the cost per mile for all of those items larger at the Back Bay. We found that the watering at the Back Bay was between $680 and $690 a mile, of which $162 is to pay for water, and $524 is for teaming and labor. At Franklin Park it is in about the same proportion when the different widths of the drives are taken into account; $103 for water and $396 for teaming and labor. Both of these items are also carried out by the square yard.

The repairs of drives and walks includes the putting on of additional material, but not cleaning, and amounts to $352, a mile at Back Bay

and $200 at Franklin Park, or 1.4 cents and 1.1 cents per square yard. The cleaning of catch basins, the removal of snow, the cost of tools and depreciation of plant are figured in here, making the total cost on the Back Bay $1793 per mile or 7 cents per square yard, and at Franklin Park $1570 or 8½ cents. At Franklin Park we have a large length of walks as compared with drives. We cannot separate the cost of the maintenance of the walks from the drives. But as to the amount of work done on the walks, where the cleaning is small compared with that on the drives, and where there is no watering, though there are some repairs, it did not seem hardly fair in getting the cost per yard or the cost per mile to figure in the whole area of those walks; so these costs per yard, etc., are got by dividing the whole cost of maintaining the walks and drives by the area of the drives and by miles of drives. This makes the statement not quite as favorable as regards economy as it should be. That is, the maintenance of the roads does not cost as much as is shown there, but I had no way of separating the cost; and I have put on a statement at the bottom that if the area of the walks is included the cost would be 5.1 cents and 5. 6 cents per square yard.

QUESTION:—What was the thickness of the Back Bay road?

MR. HOWE:—Eight inches.

QUESTION:—And twelve inches at Franklin Park?

MR. HOWE:—Yes. There is one thing I would like to speak of in connection with the Back Bay road. When we started building that form of road it was thought that as it was on a new filling, it would be wise to get along perhaps as economically as we could and not count on getting a permanent road bed there, and so we put on a less amount of material than we otherwise would and did not attempt to build the Telford road. I am inclined to think now it would have been cheaper if we had built the same kind of road as we did at the other park, as the method employed uses up a large amount of stone on the loose filling. I think that if we figured the quantity of stone used we should find that we used very near a foot in depth on that loose gravel, which is very difficult to compact by rolling. The stone works down into the sand. I tried this year using the steam roller, and I should like to get some light on the use of the steam roller on such ground. We did not succeed at all. The road would not compact. It was too soft to roll the road bed with the steam roller, so we rolled first with the horse rollers and then put on the stone and rolled it with the steam roller. We had to come to the horse roller in order to get a surface; we couldn't do it with the steam roller.

QUESTION:—That was on filled in land?

MR. HOWE:—Yes.

QUESTION:—What is the principal difference?

MR. HOWE:—The roller in going over the road would produce waves on the surface and we could not get it solid. If there is any way we could I should like to know it. The piece of road we did that way cost more than we had built there before.

QUESTION:—How heavy a roller did you use there?

MR. HOWE:—Fifteen tons.

QUESTION:—Did you use any ring roller before it?

MR. HOWE:- Only on a small part of the road except in the road bed. We used a horse roller on the road bed. We put on about six inches of cracked stone and kept adding it. I think we got on a foot before we got it rolled.

QUESTION:—Don't you think that was the reason of it, that you had too much to compress at once, that that is the reason the steam roller didn't work well?

MR. HOWE:—Six inches isn't a great deal, is it?

QUESTION:– Well, on account of the bed below being softer, if you had rolled with a ring roller first wouldn't that have brought it down to a better surface for the steam roller to strike?

MR. HOWE:—We did roll some of it with the ring roller first but it didn't seem to make much difference.

OUTLINE OF THE COURSE OF INSTRUCTION IN HIGHWAY ENGINEERING AT THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

BY FRED E. FOSS, A. M., C. E., INSTRUCTOR.

[Read February 17, 1892.]

The course of instruction in Highway Engineering as it is now being developed at the Mass. Institute of Technology consists of:

First. A course of lectures by the instructor, illustrated by a set of drawings and a collection of samples of materials used in highway construction.

Second. Laboratory tests of materials.

Third. Lectures from time to time by engineers who are engaged in actual highway work.

The course of lectures given by the instructor begins with a brief sketch of the history of road building.

The advantages of good roads are then discussed and the student led to see the waste of power caused by bad roads.

Before considering the location and construction of roads the requisites of a good road are discussed with reference to alignment grade, cross-section, drainage, surface and cost.

The effects of steep grades, the importance of thorough drainage, the advantage of a hard, smooth surface, and the necessity of considering the cost as a function of the three items, cost of construction, maintenance and operating, are taken up in order.

The location is then considered in its three parts, Reconnaissance, Preliminary and Location proper. As the students have already studied Railroad Location, this part of the subject is dealt with somewhat briefly, the difference between the problem in the case of a railroad and a common road being pointed out.

The construction is next taken up. The different problems that may be presented to the engineer, in swampy ground, sidehill work, etc., are discussed at some length and the various methods of handling earth and rock are described. The various forms of structures are described and illustrated by a set of drawings. As the student at a later period has a thorough course in bridge designing this subject is passed over lightly, simply a description, illustrated by drawings of the different types of highway bridges in common use, being given.

The road surface is then taken up, the construction of the covering when formed of the different materials being discussed. Roads are here divided with reference to their covering into earth, broken stone, gravel, corduroy, plank, charcoal and shell, the subject of pavements being taken up later on. Under the subject of earth roads the attention of the student is called to the fact that great improvement can be made by a thorough system of drainage and proper attention to maintenance. Under the subject of broken stone roads, the methods of construction used by Macadam and Telford are described together with the principal modifications which have been used, or are in use at the present time. These are fully illustrated by a set of drawings. The different methods of breaking stone, by hand and machinery, are considered and the principal forms of stone breakers are described. The different methods of rolling, by traffic, by horse rollers and steam rollers are discussed. The student is made familiar with the construction of the different forms of stone breakers and road rollers by a series of cuts. The methods of constructing gravel roads both with and without the Telford foundation are described. The corduroy, plank, charcoal and shell roads are touched upon lightly as they are of local application.

The laying out of city streets is next considered and the advantages of a combination of the rectangular and diagonal systems are shown. Maps of various cities are used to illustrate the different methods of laying out city streets. A map of the business portion of Chicago shows the rectangular system, those of Washington and Indianapolis the diagonal combined with the rectangular, and that of Boston is a good example of the absence of any system. Some attention is paid

to the width of streets and alleys and the most convenient dimensions for blocks and lots.

The various materials used for forming the surface of streets are then considered. They include not only earth, broken stone, gravel and plank which have already been described under the subject of road coverings, but also cobblestone, rubblestone, stone block, wood block, brick, asphalt and coal tar. The subject of cobblestone and rubblestone is lightly passed over as there is very little of this class of pavement laid at the present day although there is a large amount of it in existance in this country. Under the head of stone block pavement the use of the original nearly cubical Belgian block is referred to and the objections to it shown. The reasons which have gradually led to the adoption of the shape of block that is now commonly used in this country are discussed and the difference in the practice in this country and England is referred to. The advantages of a solid foundation are dwelt upon somewhat fully. Under wood block pavement, the various forms which have been used are described and the methods of construction now in common use in the western cities of this country and also in European countries are given their full share of attention. Under the subject of brick pavements the various methods of laying as practiced in different cities are described. The students attention is then called to the subject of asphalt and coal tar pavements and the essential differences between them are pointed out.

All the various forms of pavements are compared and the advantages and disadvantages of each under different conditions are discussed. The entire subject of street pavements is fully illustrated by drawings. Specifications from many of the leading cities are studied and compared. Data are being collected, giving for the chief cities in this country the amount of pavement of various kinds at the present time, the amount laid during the past year and the cost per square yard.

The subject of footpaths is next taken up and the various materials used, earth, gravel, plank, broken stone, brick, flag-stone, concrete, coal tar and asphalt are discussed.

Curbs and gutters receive a fair amount of attention and the various methods of construction are described.

The subject of bridge floors is not neglected, but the attention of the student is called to the various forms of construction that may be used.

The subject of Road Legislation is briefly discussed, the defects of the road laws as now in force in most of the states being pointed out and the efforts which are being made to remedy them referred to.

The work of instruction will be materially aided by the collection

of materials which is being formed, and which will contain as far as possible, samples of the various kinds of paving material in use in different localities.

Apparatus for testing the comparative value of paving brick and stone is to be constructed. The properties which it is proposed to test are:

(1) Resistance to abrasion and impact.
(2) Transverse strength.
(3) Absorption.
(4) Crushing strength per square inch.
(5) Specific gravity.

The apparatus for testing the resistance to abrasion and impact has not yet been constructed, but will probably consist of an iron cylinder, divided transversely into two compartments, into one of which will be placed the brick or stone block to be tested, t gether with a certain weight of iron in small pieces, and into the other a block of some standard stone, as the Quincy granite, of the same dimensions as the test specimen and the same weight of irc n. The cylinder will then be revolved about its axis for a certain length of time and the loss in weight of the test specimen and the standard specimen compared.

This cylinder can also be used for ascertaining the comparative wearing qualities of different kinds of broken stone. A certain weight of the stone to be tested can be put in one compartment, and the same weight of a standard stone in the other, both being broken as nearly as possible to the same gauge. They can then be revolved for a certain length of time and the loss of the two compared.

All the other tests mentioned can be made with apparatus already in the testing laboratory of the Institute.

That there is a demand for this branch of instruction is evident from the fact that three members of the present graduating class have chosen for their graduating theses, subjects relating to highways.

Editors reprinting articles from this journal are requested to credit both the JOURNAL *and the Society before which such articles were read.*

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THE NICARAGUA CANAL.

An Address by O. B. Gunn, Member Engineers Club of Kansas City.

[Read June 13, 1892.]

The most remarkable achievement, of this remarkable age, changing the routes of the commerce of the world, is the construction of the Suez Canal. This great canal, forms a passageway between the Mediterranean Sea, and the Red Sea, for the largest ships, and cuts the Eastern hemisphere in two, entirely severing Africa, from Europe and Asia.

The western terminus is at Port Said, on the Mediterranean Sea, and the eastern terminus, is at the Port of Suez, at the northernmost end of the Red Sea, not many miles, from where it is said, the waters parted for the Israelites to pass over, and the hosts of Pharaoh, following in pursuit, were engulfed and overwhelmed by the returning waters.

This canal is 88 miles long, was originally 26 feet deep, and 72 feet wide on the bottom, and about 250 feet wide on the top. Its course across the Isthmus of Suez is quite direct, and lies across a sandy desert, scarcely on an average, more than ten feet above the level of the sea, although it cuts through two small ridges, about 50 or 60 feet high. The excavation required, was almost exclusively alluvial, although in the two ridges referred to some soft gypsum rock was encountered. It seems almost certain, that at some very remote period, what now forms the low sandy plain of the Isthmus, was water, and that Africa was a continent by itself, and was only added to Asia by the action of the sea. This great canal is peculiar in that it is a tide-water, or sea level canal, and has no locks, or other essentials of the ordinary canal. It was built under the supervision of Ferdinand

De Lesseps, and brought him great fame as an engineer, and great profits as a promoter, projector and stockholder; and yet, when critically examined, it does not seem to be a work of great engineering features. It is simply an immense ditch, excavated out of alluvial desposits, where labor is abundant and cheap, with artificial harbors at each end of no great extent, and which any American engineer, of ordinary ability would be willing to undertake. But while this canal connot be considered as an extraordinary engineering work, it has worked, and is working, an entire and complete revolution in the commerce of the Eastern hemisphere. By reason of its construction, a direct route is furnished between all English and Mediterranean ports, and India, China and Japan, saving about 5,000 miles of distance over the old route, around the coast of Africa, and the Cape of Good Hope.

The canal has been a great financial success. Its business has increased so rapidly, that its original dimensions have been enlarged in many places, and its shares of stock have increased in value very rapidly, year by year. It cost about $100,000,000, and the market value of its stock now represents about $300,000,000 or three times its original cost.

The number of vessels passing through it in 1875 was 1,494. Its earnings were $6,020,000. In 1880 it passed 2,026 vessels and earned $8,147,000. In 1886 it passed 3,100 vessels and earned $11,546,000, or nearly double the earnings of the first year. In 1890 its earnings were about $15,000,000 or 15% on its original cost or 5% on a capitalization of $300,000,000.

The great success of this canal, both financially and commercially, at once made De Lesseps the most famous man in Europe, and his praises were sounded around the world. Lauded by his countrymen, decorated by his government, intoxicated by his great success: the hero of one continent, why should he not cap the climax of his fame, and become the hero of the world. He had severed the eastern hemisphere by cutting a canal through the Isthmus of Suez. Why should he not also sever the Western Hemisphere by cutting a canal through the Isthmus of Panama. This he resolved to do, and set about doing it at once.

Commander Lucien Bonaparte Wyse of the French Navy, had already secured a concession from the State of Columbia, to build a canal across the Isthmus of Panama, and De Lesseps decided to obtain control of this concession, and to build a sea level canal, upon a route to be selected under it. He conceived the idea of an "International Scientific Congress", made up of persons indicated by himself. The congress met in Paris, May 15th, 1879. It consisted of 135 delegates of whom 74 were French and 11 were American. The congress was in session two weeks. Commodore Ammen and Engineer Menocal,

American Engineers, who had thoroughly explored, and surveyed the isthmus, presented maps and plans of the Nicaragua route, but they were ignored, and the conference dominated by De Lesseps, decided, that the canal must be a sea level canal, and must be built parallel with, and near the Panama Railroad. Having come to this decision, De Lesseps immediately set about organizing his Canal Co. After meeting many reverses, and overcoming many obstacles, he finally issued a call for a subscription for 600,000 shares, and his countrymen showed their amazing confidence in De Lesseps by subscribing for over 1,200,000 shares, or more than double the amount called for.

The number of subscribers was 102,230, of whom more than 16,000 were women. As soon as possible after his immense success, a vast plant and outfit was established at Panama. The Panama Railroad was purchased at a fabulous price, and in due time operations were commenced. No complete surveys, plans and estimates had ever been made. The route lay up the valley of the Chagres River, which it crossed 9 times before leaving it for the great Emperador and Culebra cuts. The Chagres River had been known to rise 52 feet in a single freshet. This immense body of water would, of course, fill up, and destroy the canal in a few hours. No plans were ever made to deflect this river away from the canal, and to do so, would require a channel many times larger than the canal itself.

To give you some idea of the magnitude of this colossal work, we may compare it in a measure to starting from the Missouri River, at the mouth of the Kansas River, and excavating a level canal to Paola, Kansas, via Olathe, the canal to be dug 28 feet below the surface of the Missouri River at low water, which we will assume as tide level, and to be 80 feet wide at the bottom. Let the Santa Fe R. R. as far as Olathe, and the Fort Scott & Memphis R. R. rom Olathe to Paolaf represent Panama Railroad, from Ocean to Ocean, owned by the Panama Canal Company, and the canal running parallel thereto. Let the Kansas River represent the Chagres River, rising 30 or 40 feet in a single freshet, and the canal crosses it 9 times, before leaving it at Holliday for the divide. At Olathe and beyond, the cut would be 350 feet deep and 1200 feet wide at the top. The amount of work to be done was enormous. The estimate for total excavation was 97,630,000 cubic yards. The amount of solid rock excavation was 44,675,000 cubic yards. The amount of excavation under water was 24,747,000 cubic yards. The amount of solid rock excavation under water was 8,621, 000 cubic yards. Allowing 25,000 yards as the excavation, required to build a mile of average western railroad, and the total estimate of excavation for the Panama Canal, would build 3905 miles of railroad. The rock excavation would build 1,784 miles. The excavation under water, would build 988 miles, and the rock excavation under water,

would build 344 miles of railroad. Great as these early estimates were, they were finally found to be, only about 60% of what would actually be encountered. Add to this enormous excavation an annual rainfall four or five times as great as it is in Missouri, and a climate so destructive to human life, that there were more men in the hospitals than upon the work, and you will have some conception of the immensity of the work undertaken. The cost was originally estimated by De Lesseps at $220,000,000. After spending $260,000,000 and resorting to every possible device to raise more money, De Lesseps was obliged to give up. The money was squandered and gone, and not one-fourth the work done. The French people were furious in their wrath. Millions upon millions had been drawn out of the French peasants and tradespeople. The French government was called upon to complete the work, but after having it examined by expert, and disinterested engineers, the whole project was pronounced impracticable and was abandoned. Ten years ago De Lesseps was at the zenith of his fame, and the most famous man in Europe; now he is a ruined and broken-hearted old man, execrated by thousands of his countrymen, who dumped the savings of a lifetime, into this most impracticable, and chimerical of all engineering undertakings.

And now we come to the Nicaragua Canal, which, if De Lesseps had listened to American Engineers, and paid attention to the maps, plans, profiles and estimates made by them, he would have built upon this route, and received as much fame and glory, as he received from the Suez Canal. But Providence seems to have reserved the construction and ownership, of this great work, to Americans, and every patriotic American, ought to be glad that it is so ordered. For more than three centuries, the question of a waterway across the Isthmus of Darien, has at different times, excited the interest of the civilized world, and many projects have been devised from time to time, looking to the solution of the great problem, but it was not until 1826 that any really definite plans were adopted. In that year, De Witt Clinton, Governor of New York, and builder of the Erie Canal, associated with many distinguished men of his time, secured a concession from the Central American Government for the construction of a ship canal across Nicaragua. Their estimates in the light of present information, seem quite absurd, as they proposed to build the canal for $5,000,000. Their plans, however, failed from inability to raise the money. In 1838 Lieut. Bailey, of the British Navy, made maps and drawings for a canal, and estimated its cost at $25,000,000. In 1846 the Nicaragua Government, gave Prince Louis Napoleon Bonaparte, authority to organize a company in Europe, to construct an inter-oceanic canal, but it was abandoned by him two years later, when he was elected President of the French Republic. In 1849, Commodore Cornelius Vanderbilt, and

his associates, secured a concession from the Nicaragua Government, and a survey was made in 1850-51, by Col. O. W. Childs, and the United States Topographical Engineers decided the plan to be feasible. Col. Childs was the first to make complete surveys, substantially, over the route upon which the canal will be built. In 1858, Nicaragua granted concession to Felix Belly, a Frenchman, to construct a canal upon the route selected by Col. Childs, but he was unable to secure the necessary funds, his concession lapsed, and nothing came of it.

In 1872 President Grant appointed a commission of government engineers, and naval officers, to examine into, and report upon interoceanic ship canal communication. Eight routes were examined, and the Nicaragua route, it was declared, "possesses both for construction and maintenance of a canal, greater advantages, and offers fewer difficulties from engineering, commercial and economic points of view than any of the other routes, shown to be practicable." On the basis of this report, General Grant and associates, secured a concession from the Republic of Nicaragua, for the construction of a canal, and in 1881, a bill was introduced in the United States Senate, granting aid of the United States, to the construction of the Canal, but it met with great opposition from Capt. Eads, who was working up his Tehuantepec Ship Railroad, and by De Lesseps' friends, who had the Panama Ship Canal, well in hand, and through this opposition the bill was postponed from time to time. The failure of Grant & Ward finally caused the whole scheme to collapse. In December 1884, President Arthur, announced that a treaty had been made with Nicaragua, giving the right to the United States to build a canal across the Isthmus, within the territory of that Republic, following the most available route, from ocean to ocean. The treaty was before the senate for adoption, January 29, 1886. It received 32 yeas to 23 nays, and failed of adoption under the two-thirds rule. On the fourth of March following, Cleveland became President, and soon, thereafter, withdrew the treaty from the senate.

During all these years, and so many disappointments, the project was constantly growing in the minds of men, and especially among Americans. More complete surveys and estimates, had been made, from time to time, and it was more clearly developed, from year to year, that the Nicaragua Route was the only route for this great canal. The Creator seems at first to have designed to cut the continent in two at this place, and afterwards, decided to leave a place for the ingenuity of man, to exercise itself. At last the time came, and the men to do it. In April 1887, A. G. Menocal, a distinguished civil engineer, who had been a prominent figure in former negotiations, obtained a new concession, from Nicaragua, for an asssociation of prominent capitalists of New York, and in February 1888, Congress

passed a bill for the incorporation of the Maritime Canal Company, of Nicaragua. and here was the beginning of the end, for this is the corporation that will build the greatest canal in the world, and change the lines of commerce of the western hemisphere, and it has already the work well started, having spent more than $3,000,000 in construction, and works connected therewith. Hon. Warner Miller was elected President of the Construction Company, March 5th, 1890, and the work is now being prosecuted under his management.

In January 1891, a bill was introduced in the United States Senate, by Senator Sherman, empowering the United States to guarantee the principal and interest on $100,000,000 3% Canal Company bonds, for construction purposes; the president, to be empowered to name six directors, and $70,000,000 of the capital stock of the company to be pledged as security for the repayment to the United States, of any monies advanced, the Secretary of State to vote the stock at his discretion, and an option reserved to the United States, to purchase the same, at any time before maturity of the bonds.

This is a measure of great public policy, and ought to pass both houses of Congress unanimously. That this canal will now be built is no longer a question of doubt. That it should be built, and owned by Americans is true. That the Government should aid this colossal work, and thereby secure and maintain the control of it, is beyond question. That it will pay investors well, on their investment is certain. Its cost at the very utmost, including interest during construction, and all contingencies, will not exceed $100,000,000, or just about the cost of the Suez Canal, which is now earning 5% on 300 millions of dollars, and the earnings are rapidly increasing year by year. It is, perhaps, a fortunate thing, that the Nicaragua Canal was not built 50 years ago, or even 25 years ago. If it had been, it would not have been built on the grand scale as now planned; it would have been built too narrow, and too shallow. Steamships, like railroad locomotives, have increased immensely in numbers, size and power, within the last few years, and this canal will now be wide enough, and deep enough, and with locks of sufficient capacity, to pass the largest vessels now afloat, or that ever will be likely to be constructed.

We will now consider the details of the location and construction. The canal will have its Atlantic terminus near the old town of San Juan del Norte, called by the English, Greytown. Here was once a fine harbor, but in late years it has become filled up with drifting sand from San Juan River. The Canal Company has established a new town called America, two miles from Greytown, at the canal terminus, which is and will be, the headquarters of the Company. From this point the route extends across low, and in places, partially submerged alluvial bottom land 9¼ miles to the first lock, which is at the foot

hills of the eastern divide. This part of the canal will be excavated with immense dredges. It will be 120 feet wide at the bottom, 288 feet wide at the surface of the water and 28 feet deep. It will be at sea level. This will form part of the harbor, and is wide enough, and deep enough, to allow a continuous line of the largest ships, to lie at anchor, and ample space for other ships to pass. This is a remarkably wise provision, and shows that the engineers have thoroughly studied the situation. At the west end of this 9¼ mile stretch is located lock No. 1, with a lift of 31 feet. This lock, like all others, is 650 feet long by 80 feet in width; large enough to pass any vessel now afloat or to pass two vessels at a time of 2,050 tons each.

One and one-fourth miles beyond lock No. 1 is located lock No 2. The distance between locks No. 1 and No. 2 is partly in excavation, and partly in a basin formed, by damming a small stream called the Deseado. Lock No. 2 has a lift of 30 feet, and the surface will be 61 feet above the sea. About two miles further along, is located lock No. 3, with a lift of 45 feet. Here the Deseado is dammed, forming a basin, or artificial lake, about three miles long, and from 30 to 70 feet deep. The surface of lock No. 3, is 106 feet above the sea. About three miles from lock No. 3 is the great divide cut. This great cut is 2.9 miles long, and averages 141 feet deep to the bottom of the canal, and contains 3,000,000 yards of earth and 7,000,000 yards of solid rock. This is fortunate, as it gives slopes that will not wash, or slip and slide, and it furnishes abundance of rock to build locks, dams, revetments and dikes, for improvement and protection of the harbors, at each end. From the divide cut to Ochoa Dam is 12½ miles. Through wise location, and skillful engineering, this portion of the canal will mostly be formed of immense artficial basins, and lakes, many times the necessary width of the canal. Only 1¼ miles of this distance is wholly in excavation. At Ochoa the canal will run into the Valley of the San Juan River, and here a great piece of engineering will be done. Here will be constructed the great Ochoa Dam, across the San Juan River, which at low water discharges 11,000 cubic feet of water per second. This dam will be 1,250 feet long, 62 feet high, and will give slack water navigation 64 miles to Lake Nicaragua. It is intended to raise the entire surface of the lake, which has an area of 2,600 square miles, about 5 feet. The object of this is to save a large amount of dredging, at the head of the river, and at shoal places in the lake. From San Carlos at the head of the San Juan River, to where the canal leaves it for the Pacific Ocean, is 56½ miles. Of the 17 miles from the lake to the Pacific, 11½ miles will be excavated, and 5½ miles in an artificial lake called the Tola basin.

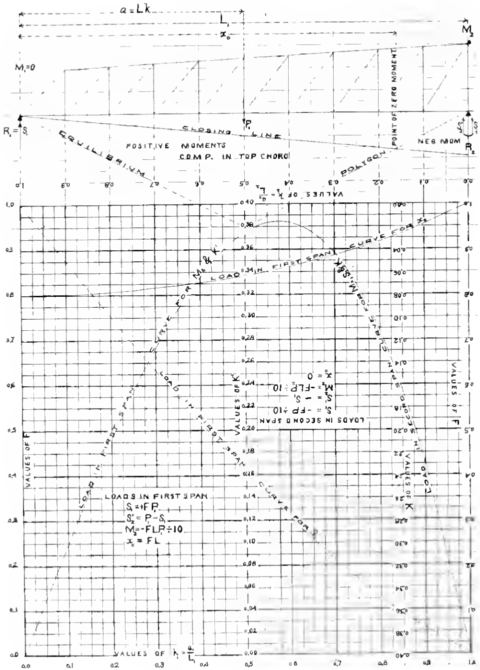
Descending from the lake to the Pacific, locks No. 4 and No. 5 are near together, and have each a fall of 42½ feet. 1½ miles further west

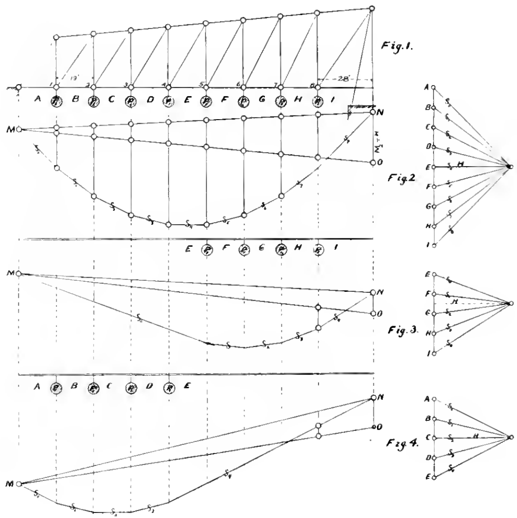
is the last lock No. 6, which takes us down to the level of the Pacific Ocean, with a fall of 21 to 29 feet, according to the tide. From lock No. 6, to Brito Harbor, is 1¼ miles, and this part of the canal is 120 feet wide at the bottom, the same as at Greytown, and is a practical inland extension of Brito Harbor. This harbor, like that at Greytown, is to be protected by heavy dikes, reaching far out into the sea, and such dredging done, as will make it safe and secure, and of ample capacity for all purposes. To sum up, the total length of the canal, from Greytown to Brito harbor will be 169½ miles, of which only 26¾ miles is in excavation, and 142¾ will be free navigation, in lakes, rivers and basins. The summit level will be the surface of the lake Nicaragua, only 110 feet above the sea. The canal and harbors will be lighted with electricity, and be operated night and day. The cost is estimated by Chief Engineer Menocal at $65,084,176. This estimate, with maps, plans and profiles, was submitted to a board of 5 distinguished American engineers. They raised the estimate to $87,799,570. On this latter basis, there is no doubt that $100,000,000 will be ample to construct this great work, including interest, and all possible contingencies during construction.

I have studied the maps, plans and estimates quite carefully, and I find little to criticise. I have no doubt that with good management, such as is usually given to works under American engineers, that the cost will fall considerably under the estimates of the board of engineers. In one thing, however, if carried out as planned, I think a serious mistake will be made, and that is in the lift of the locks. I believe, that instead of the three locks on the Atlantic, and three locks on the Pacific side, with a lift of 41½ feet each in two of them and 45 in another, that it would be much safer, and increase the capacity of the canal very materially, to build the locks with a lift in no case over 25 feet. The pressure of a 45 foot column of water, upon the gates of such a lock, would be enormous, and when the discharge gates are open, the rush of a great and long continued volume of water, starting with a head of 45 feet, would have very destructive tendencies, and if, after weeks or months under this great strain, some part of the lock should give way, it would require much time to make repairs. Four locks of 21 feet lift, and one of 22 feet would make the rise from the Atlantic to the level of the Lake, and five locks of 22 feet lift each, would make the rise from the Pacific, to the level of the lake. Added to the greater safety of the locks, would be the increased capacity of the canal. Chief Engineer Menocal estimates that a single average lockage, through his locks, will take 45 minutes, or 32 lockages in 24 hours. The great lock at Sault St. Marie, with a lift of 18 feet, is filled in 11 minutes, and emptied in eight minutes: the lockage requiring 19 minutes. A 22 foot lock then would require 23 minutes for a lockage,

NOTE.—This Sheet should be inserted in the place of the one given in the July issue of the Journal, that being incomplete.

Diagram 1





MAXIMUM STRESSES IN DRAW-BRIDGES OF TWO EQUAL SPANS.

adding five minutes for a vessel to pass in, or out, as the case may be would make 28 minutes. Mr. Menocal's locks average 36 feet lift, and he gives 45 minutes as an average lockage: but his highest lock has a lift of 45 feet, and it will doubtless take an hour, for a single lockage through this lock, and therefore, instead of passing 32 vessels, in 24 hours, it will pass only 24 vessels in that time. As a chain is no stronger than its weakest link, so the capacity of this canal, is no greater than the number of vessels that can be passed through its greatest lock in a given time. This will reduce the vessels possible to pass per year, from 11,680, as estimated by the chief engineer to 8,760 or only ¾ as many as estimated. It will also reduce the possible tonnage per annum as estimated, from 20,000,000 tons to 15,000,000 tons. Then, if it takes one hour to lock through a 45 foot lock, to lock through a 22 foot lock, as has been shown, would not exceed 30 minutes, and instead of locking 24 vessels in 24 hours, the capacity would be 48 vessels in the same time, and the capacity of the canal would thereby be doubled. When we consider the much greater security against damage, of the low lift lock, over the high lift lock, and the much less danger of getting out of repair, and the much greater facility of repairs, in case of damage, together with the double capacity of the low lift locks, I confess to much surprise at the adoption of locks with such extreme lift. The capacity of the canal is, of course, determined by the time it takes to pass a vessel through its highest lock.

The time estimated to pass a vessel from the Atlantic, to the Pacific, through this canal is 28 hours. The surface of the lake is only 110 feet above the ocean, or about as high as Fifth St. at Broadway, in Kansas city, is above the Missouri River. The lake covers an area of about 2,600 square miles, and is fed by a drainage area or water-shed of about 8,000 square miles. The lake has so great a surface, and forms such an immense basin, equal to 65 miles long by 40 miles wide, that the greatest freshet never raises the surface of the water, more than two feet, so that there never is, or can be, any freshet, in the San Juan River, which is, the only outlet from the lake to the sea.

The great lake lying at the summit of the canal, discharging when at its lowest ebb, more than ten times the amount of water necessary to feed the locks, both on the Atlantic, and Pacific slopes, when worked to their maximum capacity, is one of the most remarkable features, of this wonderful Nicaragua Canal route, and it seems marvelous, that De Lesseps, should have made the fatal blunder, of ignoring this, the only practicable route for a ship canal across the isthmus, and made his point of attack at Panama, where disaster and failure were certain.

The climate is declared to be very healthy, and quite unlike the

climate at Panama. As an evidence of this, the Company's records show, that during the year 1890, there were in the Company's hospitals 1,669 patients. Of these, there were only 23 deaths, and only 12, deaths from climate diseases, certainly a remarkable record.

The rain fall is something enormous, and almost beyond belief of a person accustomed to a rain fall of 35 to 40 inches per annum. The rainfall at Greytown for the year 1889, was 297 inches, equal to 24′ 9″, an average of over 2 feet per month, and eighty-two one-hundredths of an inch per day, the year round. We almost wonder how any work at all can be done in such a wet climate, but in the various reports I find no mention of any great inconvenience from such a tremendous rainfall.

This canal when complete, will become the great artery of commerce between London and Liverpool, and all our Atlantic ports on the east, and California, the west coast of South America, China and Japan on the west.

The canal will be on almost an air line, between New York and the west coast of South America, and New York will be actually about 650 miles nearer Valparaiso, in Peru, and all other ports of Western South America, than San Francisco now is. When we consider that the shortest distance by water between New York and San Francisco, is now 15,100, miles and that the canal will shorten it to 5,640 miles, making a saving in every through trip of 9,460, miles or nearly $\frac{2}{3}$ of the whole distance, we can appreciate the immense advantage which the canal route will possess. A vessel steaming at the rate of 350 miles per day, now requires 46 days, to run from New York to San Francisco, including three days for coaling three times. Via the Nicaragua canal, it will require only 18 days, including one day for passage through the canal, and one day for coaling, a clear saving of 28 days. This great saving in time and distance will apply equally to all North American ports, between the Atlantic and Pacific, and will attract a very large amount of traffic from the start. It is estimated that 6,500,000 tons of freight, will pass through the canal on the second year, after its completion, which at $2.50 per ton will amount to $16,250,000 gross revenue. The operating expenses of the canal cannot exceed $1,500,000 per annum, leaving $14,750,000 net revenue, or nearly 15% on the $100,000,000, which the canal will cost; and this estimate does not seem excessive, when we learn that the Sault St. Marie Canal, with its single lock of 18 feet lift, passed 8,288,580 tons last year, of freight to and from lake Superior alone.

The total transportation upon the great lakes, during the year 1890, was upwards of 51 millions of tons, and it is claimed that a vessel passes Detroit, on an average, every 7 minutes, during about 8 months that navigation is open. This vast tonnage is so great, that mere

figures do not give the mind a clear conception, of how vast it is. If it were loaded upon a train of railroad cars, each car containing 20 tons, it would load 2,550,000 cars. Allowing each car a space of 35 feet, and the train would be 17,000 miles long, and reach more than $\frac{2}{3}$ of the way around the world, and a passenger train, starting at one end of this immense train, and running at the rate of 30 miles per hour, would take 23 days constant travel, day and night, without stopping, to reach the other end.

But great as is the lake traffic, it is less than $\frac{1}{5}$ of the total of the ocean commerce of the United States. A late census bulletin, gives the transportation fleet of the United States for 1889, as 25,540 steamers, sailing vessels, and unrigged craft excepting canallers. During the year, these vessels carried 172,110,423 tons of merchandise. This freight loaded upon a train of cars, like the one already described, would reach considerably more than twice around the globe.

This will be a surprise to those who imagine that the United States, has no commerce, worth mentioning, and a greater surprise, to learn that the commerce of the Great Lakes, alone, in 1890, was greater the eight months that navigation was open, than all the tonnage, of all the vessels, entering the clearing ports of London and Liverpool, for the entire year put together.

Of this lake traffic, 8,288,580 tons was locked through the Sault St. Marie Canal lock, in 10,557 vessels, representing the commerce of Lake Superior alone, where until 1855, when the first small lock was opened by the State of Michigan,—there was almost no commerce, and it was impossible for a vessel to navigate the shallow and dangerous rapids of St. Mary's River. Now, the aggregate tonnage of the great Lakes, is 22.6% of the tonnage of all the railroads in the United States.

The adoption by this government, of the policy of commercial reciprocity, which means the exchange with other nations, free of duty, of the things that we produce, and they do not, for the things that they produce, and we do not, seems likely to prove a wise and statesmanlike policy, and by the admission into the ports of other countries, of the products of our soil, and of our manufactories, free of duty, will greatly increase our foreign trade, with all those nations which adopt reciprocity treaties, with our government. This will be true of the six republics of South America, lying or bordering upon the Pacific Ocean, whose entire trade, whether it be with the United States, or Great Britain, will pass through, and add to the revenues of the Nicaragua Canal.

The reduction of freights between our Atlantic and Pacific cities will, in the aggregate, be something enormous, and the benefit of this reduction, will be distributed over the entire country. A great reduc-

tion of rates between terminal points, more than 3,000 miles apart, means a corresponding reduction all along the line. The railroad rates on first class freight between New York and San Francisco is now $84 per ton; on second class it is $74: on third class it is $59: on fourth class it is $46; on fifth class it is $40; on tea it is $30; and on rice which is the lowest rate of all, it is $20 per ton.

When the Nicaragua Canal is completed, lines of steamships will be established between Boston, New York, Philadelphia and Baltimore, on the east, and San Francisco, and Portland, Oregon, on the west. The freight steamers will run at the rate of 350 miles per day, and allowing one day for coaling, and one day for passing through the canal, will make the trip from New York to San Francisco in 18 days. This is nearly as quick time, as the average time now made by railroad freights, between the same points. The distance by rail between New York, and San Francisco, via Chicago, and Omaha, is 3,272 miles; by steamship, and the Nicaragua Canal, it is 5,460 miles.

The average cost to shippers, for all the traffic on the great lakes, in 1889, was 1.3 mills per ton mile; at the same rate, the cost of shipping by the Nicaragua Canal, would be $7.36 per ton: add $2.50 per ton for canal tolls, and the rate would be $9.86 per ton on rice, instead of $20 per ton by rail. Increasing this rate on other classes of freight in the same proportion as the railroad charges and we have for tea, 2 mills per ton-mile; on fifth class freight, 2.6 mills; on fourth class freight, 3 mills; on third class freight, 3.8 mills: on second class 4.8 mills: on first class, 5.5 mills per ton-mile.

Then by comparison we have:

By railroad	1st class	$84 per ton:		By canal route,			$33.50 per ton.		
"	"	2nd "	74 " "	"	"	"	29.60 " "		
"	"	3rd "	59 " "	"	"	"	23.90 " "		
"	"	4th "	46 " "	"	"	"	19.40 " "		
"	"	5th "	40 " "	"	"	"	17.20 " "		
"	"	tea "	30 " "	"	"	"	15.80 " "		
"	"	rice "	20 " "	"	"	"	9.86 " "		

In each case by canal route, $2.50 is added for canal toll. This is an average of only 42% of railroad freight rates, and as an evidence that it would be a high rate, for the water route, it is only necessary to say that while the average of all freight on the lakes is only 1.3 mills per ton-mile, the foregoing estimate, is on a basis of 1.3 mills for the lowest class freight and 5.½ mills for the highest class freight or an average of 3.4 mills per ton-mile, on all classes of freight or nearly three times the average of lake freight. This is a remarkable showing, but the facts cannot be controverted. The inevitable result will be, a great reduction in railroad rates, and an increased efficiency in railroad service, a rapid and well regulated ocean service, via the canal,

and largely increased revenues to that great international waterway, and best of all, a quickening of commerce, an increased product of soil and factory, and an added prosperity to the whole country. The more we study the question, the greater the possibilities seem to be, and the more we are impressed with the feeling, that this future great highway of commerce, so vital to all our interests, must be built by Americans, and forever be controlled by the government of the United States.

Considered from a political standpoint, it is of the first importance, that the United States Government should own, or control, this canal, as against any other government under the sun. It has been the settled policy of this Government, for many years, that no European Government should be allowed to gain a foot hold, on the American Continent, or obtain control of any government, on this continent, beyond that which has existed for many years. This idea was formulated in 1823, into what is known as the Monroe Doctrine, which has existed so far, more as a sentiment, than as the settled policy of the Government.

In 1850, the famous Clayton-Bulwer treaty, between Great Britain and the United States, was signed by the President, and ratified by the Senate, whereby it was stipulated, that neither government should gain any exclusive rights, over the construction of the said canal, or erect, or maintain any fortifications, in its vicinity, nor exercise any dominion over Nicaragua, Costa Rica, the Mosquito Coast, or any part of Central America. This was a "dead give away", of the Monroe Doctrine, on our part. The English were already in possession of Mosquito Coast, with headquarters at Greytown, the eastern terminus of Nicaragua Canal, and the treaty did not clearly declare that they should vacate their position, although it was ratified by the senate, and signed by the president. Later, it was discovered, that our Government, had been greatly out-generaled, by the British Statesmen. Finally, after several years of controversy, the British Government in 1860, agreed to accept the American interpretation, of the treaty, and vacated the Mosquito Coast. But the trouble did not end here. The American Government had surrendered its right to exclusive control, of the Panama and Nicaragua Canals, if ever they should be built, and agreed to a joint control with the British Government, which was clearly in opposition to the Monroe Doctrine. Every administration since the Civil War, has protested against the Clayton-Bulwer treaty, and declared that the British Government has violated the treaty, in establishing and maintaining a settlement in Honduras, and that the United States, will maintain the principles of the Monroe Doctrine, at all hazards. President Arthur negotiated a treaty with the Nicaraguan Government, by which this government, agreed to build

the canal and own it, but it was not ratified, and when Cleveland became president, he withdrew the treaty, on the ground that it might create great international disturbances. The government took no action, when the French people began the Panama Canal, except to declare that we would never submit to have it under foreign control. After the DeLessep's failure, the French people, who had furnished nearly all the money, endeavored to have the French Government complete it, as a national enterprise, which it declined to do, partly, no doubt, from fear of international difficulties, and perhaps war with the United States.

As the matter now stands, the Panama Canal is abandoned after the expenditure of 260 millions of dollars, and the Nicaragua Canal is sure to be built, by American capital, and by American engineers.

In this connection, I quote the vigorous language of Senator Morgan of Alabama, in the United States Senate in 1890, upon this subject as follows:

"The platitudes of the Clayton-Bulwer treaty, in which each party yielded something to the other, that neither possessed, making mutual concession, for a consideration that did not exist, and could not be valuable, have become a stale demand upon the people of both nations, and there is no longer room for their serious and practical treatment. If our president and senate, can fix a theoretical, and dogmatic policy, upon our people, for all time to come, because another policy may not suit Great Britain, it seems to be in vain, that we ever attempted to divorce ourselves from the power of the British throne. There is ground for impatience, with the spirit that must first consult Great Britain, before we can know what we may do for our own people. There has been too much of that fashion of snobbishness, in American politics. All our ports are open to every British subject, the same as to our own people; yet a ship approaching the British Canadian ports, loaded with supplies for their half fed people, would be captured with guns if necessary and confiscated. British goods come and go across our soil, to Canada, in bond, and free of duty, but if we send a barrel of fish through Canada, it is immediately confiscated.

No clearer right comes to us, through the War of the Revolution, than the right of free fishing on the coasts of Newfoundland, Labrador and Canada, but we were compelled to yield those rights, won from the French, by the blood of our own people, to the arrogant demands and pressure of British aggression.

The Monroe Doctrine, was eaten away by the corrosion of British policy, in the Balize, (Honduras) and aggressions, excused by a pretentious love of the rights, of the vilest nest of freebooters, that ever assembled on this continent, grew into crown colonies, and are there now, in defiant proofs of her disregard of her treaty rights, with the

United States. If in our desire to assist the commerce of the United Staies, and to discharge the trust in favor of posterity, that grows out of the shores of the Atlantic and Pacific Oceans, by connecting through a short line of navigation, we shall offend against a lurking policy of Great Britain, shrewdly hidden in an old treaty formulation, of economic dogmas, I shall be glad very soon to have the dust removed from the hiding place, of this ancient fraud."

As soon as it was demonstrated, that the Suez Canal, was to be a great success, the British Government, with the wise statesmanship for which it is distinguished, through the astute, and wily D'Israeli, then premier, secured—through secret negotiations—the ownership of a majority of the stock of the Suez Canal Company, and under this ownership, came into possession, and control, of the new short route to the Indies and China, and they now control it as easily and securely, as they control Gibraltar, and the entrance to the Mediterranean Sea.

The British have strong fortifications also at Aden, near where the Red Sea joins the Indian Ocean, so that they have supreme control of this great commercial route. By the ownership of the Suez Canal, they can give British vessels lower rates of toll, or rebate them altogether, thus giving their vessels a great advantage over all others. This Government has but little interest or concern, in the affairs of the eastern hemisphere; and we can have only the highest admiration for the wise and far-seeing statesmanship, by which the British have secured forever, control of this great commercial route, and brought the British Isles, and their great possessions in India, 5,000 miles nearer together, but we must see to it that British statesmanship, does not in like manner, gain control of the western hemisphere.

The western hemisphere, commercially, belongs to us. Here our interests are paramount, to all others, and here we must maintain control at all hazards. Our Atlantic coast, bears, substantially, the same relation to our Pacific coast, that England does to the Indies. All our ocean commerce between these two sections of our country, if carried by steamers, now goes round South America, 15,000 miles through the Straits of Magellan, If carried in sailing vessels it has to go around Cape Horn, 2,500 miles longer distance. England saved 5,000 miles between London and Calcutta, by the Suez Canal. We save 9,500 miles between New York and San Francisco for steam vessels, and 12, 000 miles for sailing vessels, by building the Nicaragua Canal, and when built, it will become of as much greater importance to the United States, than the Suez Canal is to the British Government, as the distance saved to our commerce is greater than that saved to the British Government, by the Suez Canal.

The United States Government, must control this great waterway, and there is only one way to do it, and that is, to become a direct, or

indirect owner of the canal. By direct ownership, this Government would furnish all the money, build, own and operate the canal, as provided in the Arthur Treaty. By indirect ownership, the Government would simply guarantee, not to exceed $100,000,000 of 3% bonds, and allow the present Maritime Canal Company, to go ahead, complete and operate the canal. For security, the Government to have pledged to it $75,000,000 of stock, to be voted upon all questions, by the Secretary of State, and the Government to have proper representation, in the Board of Directors, and supervision of the expenditures. All this can be done under such restrictions, as will make the Government perfectly safe, and secure the construction of the canal in six years, and much quicker, and more economically, than it can otherwise be done. Rapid and economical construction of any great work, requires enough money provided at the start, to meet all necessary requirements. For the Canal Company to proceed in the usual way, to raise $100,000,000 will require a long time, large sums for promotion, high rates of interest on bonds, time for construction extended from 6 years to 8 or 10 years. Doubtless under such conditions as these, the canal would cost 150 millions of dollars.

Indirect ownership, by the Government, is best for all concerned, and will be much less likely to meet with international complications. If our Government declines to aid in this way, we may wake up when too late, and find that the British Government, more wise than we, has bought a controlling interest in the stock of the Canal Company, and has gathered in the Nicaragua Canal, in the same way that they gathered in the Suez Canal.

"Great ship canals like those of Nicaragua and Suez, have a relation to the commerce and naval affairs of all nations, that makes them of necessity, political factors of the most important character." As a naval and strategic point, the Nicaragua Canal, will be equal to, and greater than Gibraltar. Lake Nicaragua will afford a safe harbor, for all the navies of the world. From this point, the nation holding possession, and at war with the United States, could attack any point on the Gulf of Mexico, or on the western coast of America. It could establish a navy yard, dry dock, and coaling stations, where its vessels could be repaired, cleaned, coaled and provisioned. It could prevent the passage of the vessels, of any unfriendly power, and it could, if so disposed, and powerful enough, lay tribute on all our coastwise and South American commerce, or run it down with privateers, capture and destroy it. For the United States to yield control of this great Canal would be a national danger, disgrace and dishonor.

In conclusion I will quote the words of that noble old hero, General Grant:

"In accordance with the early and later policy of this Government,

in obedience to the often expressed wish of the American people, with due regard to our national dignity and power, with a watchful care for the safety and prosperity of our interests and industries, on this continent, and with a determination to guard against even the first approach of rival powers, whether friendly or hostile, on these shores, I commend an American Canal, on American soil, to the American people, and congratulate myself on the fact, that the most careful explorations have been started, and that the route, standing in this attitude before the world, is the one which commends itself as a judicious, economical and prosperous work."

Note.—The distances on Government Naval Charts are given in nautical miles. In this paper all distances are given in English miles, which will account for any apparent discrepancies.

SOME EXPERIMENTS ON THE EFFECT OF PUNCHING STEEL PLATE.

BY C. H. BENJAMIN, MEMBER CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Read Sept. 13, 1892.]

The experiments of which this paper gives a summary, were made in the mechanical laboratory of the Case School of Applied Science under my direction, by Mr. F. H. Chamberlin of the class of 1892, and formed a part of the work for his graduating thesis. The punches and dies used were very kindly furnished by Mr. A. E. Brown of this Club. The experiments were all made on a Riehle screw-power testing machine of 60,000 lbs. capacity, and had for their objects: first, the determination of the ultimate resistance to shearing of soft steel plate for different forms of punch, and the relation of stress to distortions as the punching proceeded; second, the determination of the effect of the punching on the elastic limit and ultimate tensile strength of the plate in the various cases.

In every test the material used was Otis steel boiler-plate one-quarter inch thick and stamped 60,000 lbs. tensile strength, the pieces all being cut from the same plate. No analysis was made of the steel, as only relative values of the effect of different punches were sought for.

The different styles of punches used are clearly shown in Fig. 1.

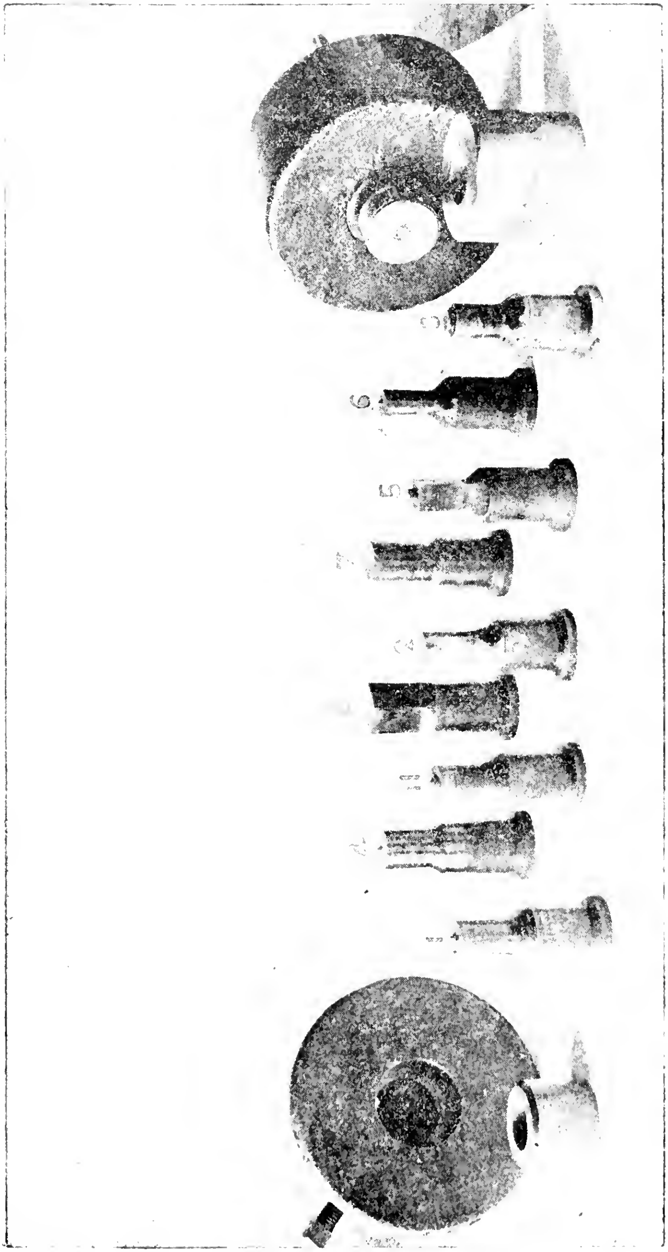


FIG. 1.

viz.: the common flat ended punch, both round and square, the center punch having a small conical center, the double punch having two steps and the spiral punch.

The punches and dies were held in the testing machine, just as they would be in the ordinary course of work, the holders being shown in the figure.

A general description of the routine of the experiments will first be given, before proceeding to consider results.

Each piece of plate used was 2 and $\frac{1}{2}''$ wide and $10''$ long. One piece was reduced in width for several inches near the center, then put in the testing machine and broken by tension, its modulus of elasticity and ultimate strength being carefully noted, also the contraction of area at fracture. A second piece was then placed in the testing machine and cut apart in double shear by a straight die, the ultimate shearing stress and relation of stress to distortion being observed. In all the experiments on shearing and punching, the distortion or sinking caused by the punch was measured by a Riehle' lever indicator, enabling the operator to read to thousandths of an inch.

Each of the remaining pieces was in turn put in the machine and a hole punched at the center of its length and width. After each was in position the indicator was applied and adjusted at zero. The machine was then run until the load reached 2,000 lbs. when it was stopped, the scale beam balanced and read, and a reading taken of the indicator.

This was repeated at intervals of about 2,000 lbs.. until the punch came through. One piece of the same steel had a hole drilled at its center to compare with the punched plates. All the plates were then taken to the shaping machine and planed on the edges to remove all cracks due to the original shearing, and also to bring the holes accurately at the center of the width.

They were then again placed in the testing machine and broken by tension, the elastic limit, the ultimate resistance, the contraction of area at fracture, and the elongation of diameter of hole all being carefully determined. In order to determine more accurately the ultimate resistance to shearing for each kind of punch used, five to ten holes were punched with each in similar plate, and an average made of the results. Fig. 2 shows graphically the relation of sinking or distortion to the load applied. for each kind of punch. The irregularities at the beginning of some of the curves may be due to springing and settling of the specimen. One fact is especially noticeable, and that is the entire absence of any yielding or breaking-down point, the curve in each case rising steadily to the maximum and then stopping.

The numbers on the curves refer to the number of plate as shown in the accompanying Table 1.

TABLE I.

No. of Plate.	Thickness.	No. of Punch.	Diam. of Punch.	Diam. of Die.	Clearance.	Max. Load.	Stress (unit.)	Remarks.
1	0.266	1	0.750	0.793	0.021	34520	55200	Rd. Center.
2	0.266	2	0.748	0.793	0.022	32000	51290	Rd. Flat.
3	0.273	3	0.766	0.793	0.013	32600	49620	Rd. Double.
4	0.275	6	0.623	0.660	0.018	26700	49610	Rd. Center.
5	0.275	5	0.623	0.656	0.016	33000	48150	Sq. Double.
6	0.271	4	1.020	1.038	0.009	41630	47940	Rd. Center.
7	0.270	8	1.051	1.078	0.018	43340	48620	Rd. Flat.
8	0.273	7	0.876	0.904	0.014	45000	47030	Sq. Flat.
9	0.273	3	0.766	0.793	0.013	31000	47200	Drilled $\frac{1}{2}$."
10	0.263	1	0.750	0.793	0.021	31400	50670	Rd. Center.
11	0.273	11	0.750	0.793	0.021	22700	35300	Spiral.
12	0.268	—	0.750	—	—	—	—	Drilled.
13	0.263	—	—	—	—	39600	49160	Sheared.

An average of several experiments gives the following results:

TABLE II.

No. of Punch.	Kind of Punch.	Average Load.	Average Stress.	Remarks.
1	Rd. Center.	32430	50010	Average of ten trials.
2	Rd. Flat.	32170	49710	" " "
3	Double Flat.	33360	51460	" five "
11	Spiral.	25360	38600	" ten ,,

Punches Nos. 1, 2, 3 and 11 were selected for a test of average ultimate resistance, as each was $\frac{3}{4}$" in diameter.

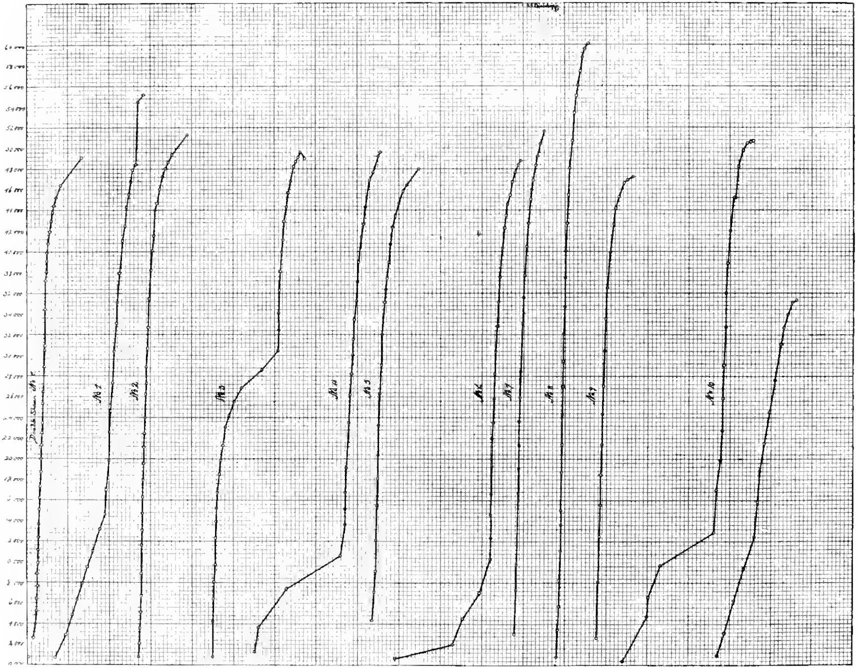


FIG. 2. CURVES FROM PUNCHING STEEL PLATE.

No. of Plate.	Thickness.	
1	0.266	
2	0.266	
3	0.273	
4	0.275	
5	0.275	
6	0.271	
7	0.270	
8	0.273	
9	0.273	
10	0.263	
11	0.273	
12	0.268	
13	0.263	

An averag

No. of Punch.	
1	R
2	R
3	D
11	S

Punches N
ultimate resis

The punches and dies were all in good condition and equally sharp. They were all such as are ordinarily used by the Brown Hoisting and Conveying Machine Company of this city, except the spiral punch, which was made in the laboratory.

An examination of Table 1., will show that, with the exception of the spiral punch, there is not much to choose between the punches used, the ultimate resistance being about the same for all.

This is confirmed by reference to Table II. It has been claimed by some that a projecting center on a punch would reduce the resistance by stretching and bending the metal over the sharp corners of the die before cutting began. The experiments do not show this. In fact No. 1., in Table 1., showed a greater resistance for the center punch than for any of the others. This is undoubtedly an error since the subsequent trials do not confirm it.

A comparison of experiments 3 and 9 shows a slight advantage in drilling a plate before punching. Experiment 13 shows that the ultimate resistance to punching and shearing is about the same.

The tests do, however, show plainly the advantage of a spiral punch over all the others, the ultimate resistance being 23% less in Table II., than the average of the other three. The resistances given in the table are undoubtedly less than when the punches are used in an ordinary press, on account of the much slower speed used and the greater time allowed for the flowing of the metal around the punch. The relative values of the different resistances are probably not affected by this to any great extent.

Table III. gives the results of the tension tests of the same plates. These results were very satisfactory with the exception of No. 10, which shows for some unexplained reason a much higher tensile strength than any of the other punched plates, although the same punch was used as in No. 1, and the conditions were precisely the same. I have accordingly omitted No. 10 in comparing averages. The variations in the ultimate strength and elastic limit of Nos. 1 to 9 are no greater than we often get from different parts of one sheet. Averaging them and comparing the result with No. 12, it is found that the ultimate strength is 7.5% less, the elastic limit 5% greater, and the contraction of area 30% less than in a drilled plate, showing that the effect of the punching is to render the metal around the hole more brittle and less ductile than before. The elastic limit was determined by simply watching the pointer of a lever extensometer attached to the plate, and the values are not as accurate as if the elastic curves had been plotted. No. 12, where the spiral punch was used shows, however, an ultimate strength only 3% less and a contraction of area only 20% less than the drilled plate, which offers another excellent reason for using spiral punches.

TABLE III.

No. of Plate.	Maximum Load.	Elastic Limit.	Stress, (unit)	El. Limit, (unit)	Cont. Area,	Elong. Diam.	Remarks.
1	24600	21020	61960	52940	22	28	
2	23110	18400	61950	49330	18	24	
3	25600	20200	61230	48330	21	28	Same punch as 9
4	26000	20480	58300	45910	23	—	
5	—	—	—	—	—	—	
6	19000	15050	62300	49340	22	—	
7	20130	15410	62900	48160	19	—	
8	23270	16400	63560	44800	25	—	
9	24100	19420	58930	47480	19	30	Drilled and Punched.
10	29130	22530	65310	50510	16	16	Doubtful.
11	29500	22600	64400	49330	24	32	Spiral Punch.
12	27800	19300	66340	46070	30	36	Drilled Plate.
14	35170	24220	69250	47700	40	—	Tension Piece.
Av. of 1 to 9			61390	48280	21		

Further experiments might determine a shape of spiral punch much more efficient than the one used.

The difference in strength between the drilled plate, No. 12, and the straight piece No. 14 may be attributed to the difference in shape of the test-pieces.

It may be said that the variation in clearance between punch and die will always affect the results, but in these experiments we had not a sufficient assortment of sizes to determine how much.

Comparing Nos. 6 and 7, in Table 1, it is seen that while No. 6 has only one-half the clearance of No. 7, there is no very marked difference in the resistances. The good or bad centering of punch and die has much to do with the results; I think an example of this may be seen in No. 1, as shown on the graphic diagram, Fig. 2. It will be

noticed that the line of pressure rises higher than the others. The same punch and die were used on No. 10, more care being taken with the centering, and as seen, a different maximum was obtained.

In the *Engineering News* for Dec. 13, 1884, will be found a translation of an interesting paper on this same subject, by a Russian engineer, V. N. Beck Guerhard. His experiments were directed towards finding the effects on the tensile strength of soft steel plate, of punching both hot and cold, by comparing the punched plates with drilled ones, and he made no measurement of the resistance to punching.

He says: "The tests show that punching cold compared with drilling decreases both resistance and elongation. In the punched holes only the top side is clean, showing a round edge, while the bottom side presents a sharp edge, in some places broken away, and drawn out with deep cavities discovering the crystalline structure of the metal. In short under the microscope we see a clear picture of the rough destruction caused by the punching."

He does not find the minute radical cracks which have been supposed to exist, but speaks of a series of curved lines appearing on the polished surface around the hole, caused probably by the flow of metal.

I intend to make further experiments in this direction, confining the tests to one size of punch, but using as many varieties as possible, and paying more attention to the effect of clearance.

The paper was followed by quite a long discussion on the subject presented.

DISCUSSION.

Mr. Porter said that the question of the resistance to punching was not of so much importance; that the practical question was in regard to the effect on the strength of the metal. He said that the trouble with most experiments of this kind was that they did not always reproduce the actual conditions obtaining in practice.

He suggested pulling the test-piece apart by means of a pin passed through the hole instead of by gripping both ends, as more nearly representing the conditions under which the metal gives way in actual construction.

Mr. Woods mentioned the use of a cup-shaped punch and Mr. Palmer spoke of a punch which was chamfered at two opposite sides so as to give shearing action.

Mr. Gifford said that the reason why spiral punches had not been used was because the great expense of making them.

It was suggested that the spiral punch would be less apt to crowd over if the spiral were double with points on opposite sides of the punch.

The fact that some of the experiments showed an apparent difference in the quality of two pieces of steel from the same plate, brought up quite an animated discussion on the unreliability of steel in structural work. Prof. Langley suggested that it might be advisable to test steel members for homogeneity by chemical analyses at various parts of their length.

"THE RAILWAY PROBLEM OF CHICAGO, IN RELATION TO TERMINALS, RAPID TRANSIT, MARINE COMMERCE AND RELATED INTERESTS."

Discussion on Report of Committee to the Western Society of Engineers, Presented May 11, 1892.

Mr. O. Chanute.

There are probably other gentlemen here who wish to say something on this subject, and I shall endeavor to be brief in my remarks. I have made some notes to keep myself in bounds.

I regret to be compelled to differ from many of the views expressed by the Committee, but I shall now discuss only two of them: one especially referring to the proposed closing of the present harbor entrance to the river. This, as it seems to me, would largely destroy the values of property in the present business center and result in changing the business locality of many industries and merely transferring elsewhere the location and pressure of traffic. You all know how the city has grown up, how the river has been utilized, how large elevators and great steamers and warehouses have clustered near the mouth of the river; how the business houses have been built in close proximity to the river, and next to them have grown up office buildings, and it appears to me that if the river entrances should be abandoned, it would result in transferring the business elswhere: that we shall only have changed the location of the business, while we shall have entailed terrible loss upon values in the existing business center.

The avowed object of closing the river entrances is to do away with the bridge nuisance. But before recommending so serious a step as the doing away with the main river entrance, it seems to me it is incumbent upon us, as engineers, to consider whether we cannot devise some plan by which the nuisance can be abated or diminished. As engineers we ought to suggest and endeavor to carry out plans for the enhancement of values, and not for their destruction.

The Committee in its report mentions the possibility of adopting

tunnels, but it dismisses the proposal very summarily in consequence of the length of the required approaches, which, it is assumed, would extend back a quarter of a mile from the river. It does not seem to have been considered by the Committee that these approaches might be made in a variety of ways; that if it be desirable to bring the traffic close to the water's edge, they might be made on a circular inclined plane, as in England, nor do they seem to have considered that traffic could be lowered or hoisted to tunnels by means of elevators. Those two methods might be considered, although I do not think they would offer the best solution.

Now the pressure is not so much due to the foot passengers on the draw-bridges across the river, but it is due chiefly to the teams that are constantly crossing. It is due to the large quantities of goods which have to cross the river, and it is the pressure of teams which is rendering the bridges such a nuisance. I question, myself, whether a circular inclined approach for teams would be the most satisfactory solution, and there are engineering devices which, it seems to me, it would not be impossible to apply. I refer to elevators and to street Railways, which have been applied to the conveyance of passengers, and which may be modified so as to apply to the transit of teams.

With regard to elevators, it may perhaps be practicable to have a sufficient number to lower or to hoist the traffic to high bridges over the river, placed sufficiently high to clear the masts of vessels, but they would occupy a great deal of space, and so the room required for team elevators might be more, perhaps, than the ground would admit of. Then we would have to consider the time that would be lost in the use of elevators, for while it would only take about fifteen seconds to hoist a team to the required distance, yet the delay in loading and unloading would cause great loss of time. I believe better results could be obtained by the adaptation of the street railway to the conveyance of teams.

We all know that the existing tunnels afforded little relief, until the railways were laid in them. They were operated for years, and very few people would travel through them, but since the street railways have been laid through them, they have prooved to be very useful for passenger traffic. Perhaps the same device can be applied to team traffic. If, for instance, tracks were to be laid in new tunnels, and if such tracks were equipped with trains of low flat cars, hauled by cable or electric power, and if such trains were loaded with teams, to be started every minute from either terminus, they would be able to transfer across and under the river a very great number of teams. My calculations indicate some 12 to 18 hundred teams per hour, this being about the present traffic of an ordinary bridge.

But the moment that cable or electric power is substituted for

that of animals, much steeper grades can be adopted, probably 10 to 15 per cent can be used, thus reducing the approaches to the tunnels from 1,350 feet, as indicated by the committee, to 540 feet, and making the length of the tunnel and approaches about one-fourth of a mile, which at the rate of ten miles per hour can be traversed in one and one-half minutes. I do not say that this would be an absolute solution of the problem of transporting traffic across the river, but it is worth considering.

Perhaps still another disposition could be made of the difficulty by means of the "multiple traction" travelling platform which is in operation at Jackson Park. I confess that I have my doubts about it, because of the difficulty in inducing horses to step upon a moving platform.

Whatever plan is thought preferable, there are many details which will have to be considered before it can be pronounced as practicable. Those I may at some future time discuss at greater length, but I may say now that I doubt whether draw-bridges can be entirely abolished, for it should be remembered that foot passengers will always prefer to remain above ground rather than to go under ground, so that perhaps such bridges as are now the least objectionable might remain for general use. It is possible, also, that a satisfactory solution might be worked out with high bridges and steam elevators: at least it might be well to consider a plan like that. All these are but suggestions, and I make them for the reason that we, as engineers, ought to consider the best remedy for the existing nuisances, before proceeding to recommend so radical a plan for their abatement as the abandonment of the present harbor entrance or the making of a new outer harbor. It is well therefore for us to inquire whether some of the schemes which I have mentioned could prove sufficiently effective to answer.

I am also unable to agree with the Committee in their report on the Railway Problem. The majority report seems chiefly to favor a depression of the tracks; it gives us a sort of a mixed plan, yet the report chiefly conveys that impression. It is not specifically stated how much the tracks should be depressed, but inasmuch as the streets are proposed to remain "at or near their present grades", the depression involves open cuttings from sixteen to twenty feet deep. This would be very difficult to drain anywhere, and be quite impracticable for those Roads which are near the river.

In the minority report it is proposed to raise the tracks, and as this seems likely to involve enormous difficulties if done upon the existing rights of way, it is proposed to combine the roads into three groups of elevated railroads, presumably to avoid the necessity for grade crossings between them.

Now the traffic in different parts of the city has grown around the

Railroads much in the same way as the marine traffic has clustered about the river. In early days when the railroads came here, the people were glad to get them, and gave them rights of way through the streets to reach convenient depot grounds, and so the traffic has grown up around these railroad centers: it produces congestion and the people find this a good deal of a nuisance and propose radical plans for removing the tracks, to the possible great injury of the commerce of this city. I think it well for us to inquire whether the remedy might not prove worse than the disease, unless carefully planned and carried out.

It seems to me that the proposal to remove the whole, or even a majority of the existing tracks from their present position at the surface of the ground, is likely to deal a severe blow to the prosperity of the city, by increasing the cost of transacting its business. This refers more particularly to freight, for in order that Chicago may continue a large distributing centre, freight must continue to be handled with the utmost economy and in the shortest time possible. If goods arriving here or shipped away are to be lowered or raised some twenty feet, special plans would have to be provided, involving a large expense in building and in operating; but, what is much more important, it would cut off from easy rail connection many manufactories and establishments now served by means of switches, and compel them to resort to the expense of hauling the freight to the elevators with teams. Goods are now taken directly from the cars by the manufacturers in many cases, and if you should compel the manufacturers to build elevated side tracks or to haul those goods by team, you would so increase the cost of transacting their business as to drive them out of the city.

If the proposal be to elevate the main running lines only, and to transfer freight cars to the existing tracks by lifts, a little consideration will show that the subsequent distribution of these cars, along the ground, either with capstans or switch engines, must prove practically as great an obstruction to the street traffic as now exists. Moreover, at various establishments, some distance away from the main yards, there would be few cases where lifts could be economically worked for the few cars received or shipped each day, especially as being thus cut off from the use of switch engines, they would have to haul the cars to and from the lifts by capstans or horses.

From my own observation, I believe that the various plans for handling cars by capstans in England and France are materially more expensive than our system of handling freight cars with switch engines. It is cheaper to use capstans than to push cars by hand or to haul them by horses, but I do not believe it is as cheap as to move them by switch engines. A short trip through the lumber regions in

this city will satisfy any one as to the difficulties of moving freight without the use of switches and switch engines.

But it is impracticable to deal in generalities and to propose a single remedy to be uniformly applied. I do not believe that there is any one patent medicine which can possibly cure all the ills of the present railway system in Chicago. Many of the roads come in along the river, and there, in my judgment their tracks should remain upon the ground, while the streets should cross overhead, as they do now. Railroads that come in along the river or the lake, where there is no traffic beyond them, should not be compelled to raise their tracks. Where the tracks are situated inland, away from the river or lake, and where the cross street traffic is large, some of the tracks should be raised, some depressed, and some should remain upon the ground, according to local circumstances. I admit such a scheme would be complicated to work out, but it is to be regretted that the Committee made no attempt to consider it, as even if crude it might form a basis for future elaboration. It is to be regretted that they have given us no definite plan for overcoming the difficulties between the railway and the street traffic, by indicating the localities where the planes of travel can best be separated in each of the five several ways which are mentioned in the report.

In point of fact, the problem is working itself out, on the basis of adaptation to local circumstances, and by special bargains between the parties interested; but it seems desirable to have some general scheme to work to, so that one set of bargains shall not interfere with another. In this connection, I would refer you to the report of the Rapid Transit Committee in Boston, concerning the proposed rearrangement of the tracks in that city. It is a very able document, and it will be better to examine it for yourselves than for me to try to tell you the main points in it. The scheme proposed may need revision, but it is a very honest and able attempt at solving a problem that is nearly as complicated as that of Chicago to-day.

In considering a plan, a proper distinction should be made between passenger and freight traffic, chiefly because of the difference in the required speed of trains. I think that where the roads are not near the river, the canal or near the lake, the passenger tracks should preferably be elevated, where there is dense street traffic, and that this would admit of an increase of their urban and suburban passenger traffic.

Freight tracks would have to be dealt with in a variety of ways, and the most complicated portion of the problem will be how to deal with them so as to abate the crossing nuisance, without driving a good many industries from the city by increasing the cost of transacting their business. In point of fact, the problem in my mind almost as-

sumes the shape of an inquiry whether a plan can be devised which shall provide increased facilities, so that the merchants and manufacturers shall be still better served, and that, as much as possible, the goods handled shall go direct into the car from the warehouse, and into the warehouse from the car.

The raising of some of the tracks would involve a large expense, and what inducement can be offered to the railroads to compensate them for the large expense they would thus incur to abolish grade crossings both with the streets and with each other? I have sometimes thought that by granting them additional privileges, to lay new tracks upon certain streets, in some districts where the grades of the streets can be raised so as to admit of Railroad traffic being carried on under them, a sufficient inducement might be offered. The streets all being raised up and the railroads remaining on the ground, the property would then be worth more for manufactories, than for the purpose of erecting cheap dwellings or neighborhood stores that those districts are now put to. But such a plan cannot be worked up by a "commission of engineers", it can only result from a bargain between the railroads and the city, and it seems to me that before we can pronounce ourselves very clearly upon the remedy to be applied, not only is it necessary to consider the various complications of the problem, but also what inducements could be offered to the railroads to carry out a scheme, and in what way a bargain can best be brought about between the railways and the city authorities.

Mr. E. L. Corthell.

Mr. Chanute has discussed this matter from his long experience, and no doubt from the very careful study which he always gives to such subjects, but yet I cannot fully agree with him in reference to the inability or expense which the railroads may be put to by handling the business of this city from an elevated terminal entrance. On the Railroad which I have built as a terminal entrance into this city, during the last three years the question came up over two years ago as to whether it was practicable to raise the tracks. The companies interested saw that it was advisable to do so, if for no other reason than to avoid one very expensive viaduct which the company was required by ordinance to build involving three or four hundred thousand dollars expense, and others which would soon follow where the streets cross these six or more railroad tracks. I think every one associated with these companies was anxious to raise the tracks. They would have been raised at that time if it had not been that about a dozen industries were connected by tracks with the Chicago & Alton Railroad. That company did not see any practical way of handling the business by an elevated entrance. These industries were coal and

lumber yards, elevators, planing mills, and that variety of industries which is found all along our railroads in the city near the river. If I had known myself as much as I know now, I believe I could have convinced the Alton company that it was practicable to handle that business economically from elevated tracks. Knowing the special conditions that exist in nearly all of the dozen cases and familiar from examination of railroad terminals and the way cars are handled in foreign countries, and from examinations of them in this country, I am satisfied that in each of these special cases an elevated terminal would have done the work. I would not have advised then, nor do I now, that all the tracks should be lifted to the level of the elevated entrance, but that the cars, by the hydraulic plan, should be dropped to the surface tracks, and then by capstans, for as great a distance as it is economical to use capstans, shift the cars to the coal yards, etc., along the river where the streets do not interfere; then where the distance becomes too great for capstans put on switch engines and let them bring the cars to the capstans and let the cars be lifted by the hydraulic lifts to the overhead tracks.

At the White Cross station of the Midland road, London, the tracks cross the Metropolitan District Railway, which is an underground or depressed railway, and all the business from the White Cross station on the street, above, must be carried some little distance on a level from that station and then dropped by hydraulic lifts to the level of the District tracks, and then be carried on their tracks to the Midland railroad on the opposite side to be put into trains and hauled away. This business is done mostly in the night, for the reason that the Metropolitan District railway has an immense traffic during the day, and the Midland cars cannot cross except at certain hours. On an average, a loaded car is lifted and hauled by capstans to the terminal of the White Cross station on the level of the street and one lowered to the level of the Metropolitan District and put on the tracks of the Midland road, every minute. The speed with which this is done astonishes every railroad man that has examined it.

The Western Society of Engineers, which constituted the Committee, the railroads terminating in Chicago, which encouraged and assisted it in its examinations, and the general public, all had a right to expect from the Committee after its two years' work, something definite in the way of recommendations as to the solution of the railway problem.

The Committee should have given in its Report as much importance and attention to the railway problem as to its related interests. This it has not done, nor has it done more in regard to the main question than to present briefly several alternative suggestions, disappro-

ving of each but strongly suggesting depressed railways and tunnels as having the greatest advantages.

I cannot agree with the majority of the Committee in its treatment of the railway problem, nor in its evident encouragement of the scheme of enlarging the waterway to the seaboard by building a ship-canal 375 miles long through New York State, from Buffalo to the Hudson River. As to the latter question, I would ask the members of the Society to again examine my paper on An Enlarged Waterway Between the Grest Lakes and the Atlantic Seaboard, which was read April 1, 1891. All of the routes which have been suggested are there discussed, estimated on, and the time and cost of transportation given.

I am decided in my opinion that the construction of an artificial channel costing probably $300,000,000, is not only impracticable, but that it is a waste of time to discuss the question; and I am further of the opinion that the only possible route by which deep-draft vessels may be carried to the seaboard is down the St. Lawrence River. The route suggested in the paper referred to as better than all others, is that via the Ontario Ship-railway between Georgian Bay and Lake Ontario. This route would not only open communication for deep-draft vessels to the seaboard, but it would also place the ten United States ports which have rail terminals on Lake Ontario, within reach of this deep-draft route. From these ten ports, extending from Buffalo to Ogdensburg, the products destined for Atlantic seaboard ports, from Portland South and for the interior cities and districts could be more economically and more advantageously distributed by the railways and by the present Oswego and Erie canals than they could be by ship canal extending from Buffalo to the Hudson River. The magnitude and consequent cost of the proposed enlargement of the Erie Canal will be appreciated from the fact that this ship canal must take its water from Lake Erie, there being no adequate supply elsewhere. This requires a uniformly descending gradient from Lake Erie to the Hudson River, which would lift the water in the Canal at some points fifty feet above the water courses like that at Seneca River, and such a Canal would require practically a new route the entire distance even in the Mohawk Valley, where the only possible method of carrying such a route through would be by slack water navigation and the construction of dams every five miles or thereabouts across the dangerous Mohawk River. Even if such a ship-canal were built on the dimensions that have been proposed, it could not possibly accommodate the immense traffic which its advocates estimate for it.

As to the railway problem, the statements and opinions of the majority of the Committee in reference to the subways and tunnels require discussion.

The Majority Report itself mentions the greatest obstacles to be encountered in both methods, but dismisses them as easily removed, without stating just how the removal should be accomplished. The statement that the open cuttings would in most sections of the City be through clay nearly impervious to water is not fully in accordance with views expressed in a recent discussion of Chicago foundations by those entitled to be considered experts on the subject. The following extracts are from that discussion, as printed in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES:

"MR. PURDY:—It varies widely, but it is stiff and soft alternately. Generally the surface clay, that which comes nearest to the top of the ground is hard, harder than below, and yet under one of the buildings that is now being built, one of my employes found that his weight was sufficient to push a shovel its entire length into the clay."

"PRESIDENT COOLEY:—As Col. Burke is not here, I will tell a story and attribute it to him. I believe that I can quote him as authority for the statement that there are six or eight places in the river where they have dredged down, and on coming back they found that the bottom of the river had come up. This is ascribed to the high buildings in the city exerting such a pressure that the soft strata are forced up. * * * * * The general question arises on account of the City being built to a certain extent on a sub-stratum of soft clay, is that substratum continuous over the site of the city and is it desirable to perforate through it by means of piles or cylinders with a view of reaching permanent strata?"

"MR. C. T. PURDY:—It is a well established point that to drive piles through a hard area, letting them just break through into a soft medium is bad engineering. It has been my experience that the strata varies greatly, and I think the borings that have been made by different engineers in the city will bear me out in that statement."

"MR. BENEZETTE WILLIAMS:—But I wish to say a word in regard to the clay underlying the city, especially with reference to what Mr. Purdy has said. The experience of driving tunnels through Chicago soil is that on a given level and substantially the same distance from the rock, and the same distance from the surface, you will pass through a very soft clay into which you can run your finger to clay of an entirely different character. The clay lies in irregular masses in pockets, alternating hard and soft. Nothing systematic about it. Any building that is founded here is founded on just such material, it is not homogeneous or uniform or in horizontal layers and it is a wonder that those buildings stand as well as they do to-day."

As the question of stratification, and the character of material underlying the soil is of such importance in this discussion, it would be well to call not only upon the members of the Society who have given opinions in regard to it, but I would suggest that Gen. William Sooy Smith, who has probably had more practical experience in the line of his professional work than any other man, should set us right upon this point.

The character and the stratification and the material through which the subways and tunnels must be built varies so much in different parts of the city that any opinion is hazardous, but if we were to plan a subway laid south from Twelfth Street to Englewood, running

west of State Street, where probably an elevated or depressed railway would first be built, the material would be something as follows, on an average, with wide and constantly changing variations:

For a distance of about six feet below the street level we would find filled material. There then would be six or eight feet of sand, and then from one to four feet of hard blue clay, then soft blue clay, changing constantly in consistency to a depth of forty or fifty feet until we reach the material immediately overlying the rock.

Between Englewood and Twelfth Street there are over fifty streets crossing the line of this depressed road, which have sewers in them varying from one to seven feet in diameter, the grades of which are from eight to twelve feet below the established street grade. Most of these streets have water pipes also which lie from five to ten feet below the grade, also gas mains which are at a lesser depth. The top of the rails of a depressed railroad should be at least eighteen feet in the clear below the underneath side of the street bridges, or about twenty feet below the street grade, with an additional depth for drainage. The bottom of the excavation will therefore be eight or ten feet below the water level of the Lake. All falling and seep water must be pumped out by steam or other power. All sewer water also must be pumped by the same method, for the suggestion of the majority of the Committee that syphons might do the work could hardly be carried out in practice as there is not sufficient fall or head to work syphons.

The cost of constructing a four track subway through the varied material above described, providing pumping arrangements for water and sewerage, cutting and changing all sewers and pipes of every kind and building the street bridges, would no doubt exceed the cost of an elevated railroad for the same number of tracks.

In comparing this method of a subway with that of a four track elevated railroad, the fact that the latter when constructed with its solid, water-tight floor, has the same space underneath all ready for tracks, yards, storehouses, warehouses and all the other business required, in connection with the upper level tracks, should be taken into consideration. It is suggested by the majority Report that the entire area over the subway tracks could be floored over. The cost of doing this should be added to the cost of the subway to make a fair comparison with the elevated method, and if it were done there would result a tunnel with its dark and vitiated air instead of daylight and the pure air of the elevated structure.

A tunnel or partially covered subway cannot be kept free from smoke and gas. Those accustomed to the air in the Metropolitan District roads of London will appreciate this. Nor would the air in the tunnel, even if it were operated by electricity, be free from impurities:

nor would the air be wholesome. The air in the tunnel under the Thames in London is not pure air. The Sarnia tunnel under the St. Clair River, although coke is used instead of coal, is so filled with gas and foul air that the brakemen on the freight trains can scarcely live in it. Almost any tunnel that might be mentioned in the case, is objectionable on account of gas and smoke and bad air. In the St. Louis tunnel especially in warm weather, the air is so bad that it is a frequent occurrence for ladies to faint while going through. The windows and ventilators shut, in order to go through the tunnel and not breathe noxious gases. About a week ago I came through the tunnel at Baltimore, and while it has two or three good ventilating shafts, yet it was exceedingly annoying to pass through the tunnel on account of smoke and gas.

In presenting the minority Report in which definite methods by an elevated structure are given, I base my statements and opinions on examinations of many of the terminals in Europe. I remember very well at Antwerp, and many other places, of taking special note of just such methods by which the traffic is handled by means of cranes and lifts and moved to the exact point where it is wanted, and moved very quickly on tracks to be elevated or lowered, as required. I am confident that the principle of handling traffic by this method can be adapted to every possible special case that may arise in this city even where it is absolutely necessary or best to maintain the tracks on the present surface, as at some of the grain elevators and industries of various kinds, as well as some of the river piers and docks. The loaded or empty cars can at very small expense and with perfect convenience and with no appreciable loss of time, be transferred from the high to the low level and then run out into these buildings and yards by the means so skilfully employed in Europe, by hydraulic capstans, traversers and turn-tables, and they can be then handled by cranes and lifts at will. Hydraulic power in handling cars and freight is immeasurably superior to hand labor, no matter how conveniently the latter works. The general results and opinions in Europe, so far as my observations and inquiries went, are that it costs less than one-half, and that in very many cases the business could not be handled at all by manual labor. Comparing steam and hydraulic cranes, the latter are much less expensive. In the five years from 1875 to 1880, at the Port of Calcutta where steam and hydraulic cranes worked along side of each other the cost per hour of the steam cranes averaged four times that of the hydraulic cranes.

The question might be asked, how could bulky freight be handled, such as machinery, bridge girders of great length, long piles and other such freight. The hydraulic system when once completed is capable of indefinite extension and great variaties. In addition to the lifts

for the cars described in my minority Report, cranes worked by the same power can be placed on the upper or lower level and these bulky freights be lowered or raised outside of the main structure and be placed on cars or on trucks, as may be desired. These cranes can be located at points where it is found most convenient to handle such freight, and they could be so arranged as to run on tracks with flexible water connections, as at many of the docks and railroad terminals in Europe.

It is due to all of the interests for whom we have undertaken this examination and the solution of this railway problem, that we should bring to the subject our very best skill and all the knowledge which we have obtained by reading or by observation, and I think it is desirable that experts should be invited to contribute to the discussion of this report, and when the discussion is completed, I would suggest also that the Secretary of the Society, or perhaps some one selected specially for the purpose, make a digest of the reports and discussson in order that the salient features may be brought out in suitable form for the benefit of all interested.

Mr. A. Gottlieb.

The subject of the report is so important and so vast it can hardly be done justice to in a few minutes, and so vital to our city, that a man must be careful in expressing his views, if he wishes to say anything about it. I have read the majority report and the minority reports very carefully.

I agree in one respect with Mr. Corthell, namely, that the majority report treats so constantly of our Harbor and River facilities, and devotes but a very little portion to the Railroad Problem. I find that over twenty pages of the majority report contain matter with reference to the River and Harbor, and only about eight pages, and that in a very general way, treat about the Railroad system. There are thirteen tables attached to this report showing the immense traffic on the lake and river, and not a single table showing the important traffic on the streets in the City of Chicago. I think that the Committee should have considered that, while we are well acquanted with the traffic here, the general public outside of Chicago is not.

We have here a city in less than one square mile, composed wholly of business streets. Take the district from the river on the west side to the lake on the east, and from the north branch of the river, or South Water street, to Twelfth street, and it is about what we call the business district of the city, and it would be astonishing to know how many passengers are brought into this district in the two hours in the morning, and taken out in the evening, by the steam, street and cable cars. Our suburban traffic and passengers that are brought in

by the steam railroads, is a subject that very few of us have a correct idea of, and I would like to see papers coming forward in order to prove the necessity of something being done.

The question is, What can be done? The outlay of money will be immense, no matter what is done. We should recommend feasible ways, which could be carried out without imposing great burdens on the railroads, and some way devised, in fact, that other interests might contribute to the outlay of changing the present system. In that respect I agree with Mr. Corthell on a system of elevated roads, instead of depressed subways, and that they would ultimately have the passenger traffic. It is the passenger traffic which I have in view, because it needs to be handled rapidly. Freight does not need to be handled rapidly, but passengers must be handled rapidly, and with safety to themselves and safety to the people crossing tracks and streets.

In the second place, the elevated roads do not need to be established through the whole city, but through certain districts only, and beyond those districts, tracks could be elevated partly and streets depressed partly; and so it would be a very small outlay comparatively, and by combining the two systems I think immediate relief could be obtained on a great many of the railroads and they could be extended as the city grows up and builds up.

As far as the system of three great traffic lines is concerned, I would substitute five, for this reason: We have at present six terminal stations in the city, and so far as I know only one, the Illinois Central, which is on the lake has no traffic crossing their tracks, except far out. The other five railroads have formed combinations with companies which are on friendly terms with those railroads, who own rights of way leading towards those terminal stations, and other costly properties along those lines, that it would be difficult for them to have only one station on the West side and one on the North side, and they would not accommodate the great traffic.

I would say, in a general way, I think that the elevated railroad system would be a proper solution of this question, but as Mr. Chanute says, it is hardly possible that any one thing would cure the difficulty. Under any circumstances, I would say for the present the freight traffic should be left alone, on the level of the ground, as there are so many interests connected with it which could not be served by an elevated system, and before we come to the hydraulic lift system it will be a long time. Our railroad systems are entirely different from those in Europe Those European railroads - - - roads hundreds and thousands of miles long have the same owners to-day as fifty years ago, are largely owned by the States. Those owners are able to improve their property in every possible way, while most of our roads

change hands frequently. The improvements they think of are such as are absolutely necessary to keep the road running. As long as that is the case, you cannot expect millions will be expended in carrying on improvements. It may be done when we are on the same footing and under the same conditions as those European railroads, but to make the rule general, I do not believe it can be done. So I say that to try to obtain the possible is better than to study lifts, which under the circumstances are not likely to be adapted generally. Elevate the passenger traffic and let the freight be where it is for the present, and that will solve the problem for a good many years.

I would say, that while the freight traffic might remain on the ground, it is greatly relieved now, and can still be more relieved by transfer yards outside of the city, and no doubt a policy will be devised for the future that will bring still more relief than we have to-day.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

WESTERN SOCIETY OF ENGINEERS.

293RD. MEETING, JUNE 15, 1892:—The 293rd. meeting of the Society, being a Special Meeting for the continuation of the discussion of the Report of committee on "The Railway Problem of Chicago etc., etc." was held at the rooms of the Central Traffic Association, The Rookery, on Wednesday evening, June 15, 1892, at 8 P. M.

President Randolph called the meeting to order and explained its object. Minority reports were read from Mr. E. L. Corthell and Mr. Isham Randolph. The discussion was then continued by Mr. O. Chanute, Mr. E. L. Corthell, Mr. A. Gottlieb and Mr. A. W. Wright.

The meeting then adjourned. JOHN W. WESTON, Secretary.

The Annual Summer Meeting of the Society, held on September 1st., comprised a railway trip over the B. & O. tracks to the World's Fair grounds at Jackson Park, by the courtesy of the officials of the Baltimore & Ohio Railroad Co., an inspection of the buildings as far as time would permit, and a lunch, served in the Mines and Mining Building, by the courtesy of the World's Columbian Exposition Executive. The following programme covered the days exercises which were participated in by some 200 members and guests.

Members and guests took B. & O. Special train at 9:30 A. M. at Grand Central Station and reached the World's Columbian Exposition grounds between 11 and 12; they spent the time until 2 P. M. about the buildings.

At luncheon in the Mines and Mining Building the order of exercises was as follows:

Music, Mandoline Orchestra: Address of Welcome:—Isham Randolph; Christopher Columbus:—T. B. Bryan: The Architects of Chicago:—W. L. B. Jenney: The Electricians of Chicago:—Mr. De Land: The Wife of the Engineer:—Gen'l Wm. Sooy Smith: The Engineer's Sweetheart:—W. L. Stebbings: The Western Society of Engineers:—Prof. Ira O. Baker; Toastmaster:—Willard A. Smith.

At 5 P. M. train was taken for Chicago which terminated a pleasant meeting. JOHN W. WESTON, Secretary.

294TH. MEETING, SEPTEMBER 7, 1892:—The 294th. meeting of the Society was held at the rooms of Central Traffic Association, The Rookery, on Wednesday evening, September 7th, 1892, at 8 P. M. President Randolph in the chair and some 20 members present.

The minutes of the last meeting were approved, and the Secretary reported that the Board of Directors had met on two occasions with the committee on "Amendments to the Constitution and By-laws" and that work was still under consideration.

Mr. Appleton, chairman of the above committee reported progress and expected fully to have the matter ready for presentation at the October meeting of the Society in order that a final vote may be had in time for December business.

Mr. D. C. Cregier for the Committee on Ericsson Monument stated that the committee was not yet fully organized.

Mr. G. A. M. Liljencrantz. chairman of committee on "Badge, Seal etc." presented a report.

A general discussion ensued on the subject, Mr. D. C. Cregier suggesting that so far as the Seal was concerned he saw no object and much inconvenience. with many possible legal requirements in effecting a change.

A motion was carried that "The committee on 'Seal, Badge etc.,' embody in their report their recommendation relative to the change of the Seal."

Some further discussion ensued on the changes in the design of the Diploma. but no final action was taken.

The secretary then read a letter from the American Society of Civil Engineers, asking the assistance of the Secretary in the work of obtaining papers for the "Engineering Congress" in connection with the World's Columbian Exposition of 1892.

The Secretary earnestly urges members of the Western Society desiring to present papers to communicate with him without delay.

Mr. G. A. M. Liljencrantz then offered the following resolution which was unanimously carried:

Resolved, that the thanks of this Society are due and hereby tendered to the Board of Control of the World's Columbian Exposition and to the official Staff of the same for the freedom of the grounds and buildings and courtesies extended to the members and guests of this Society on the occasion of their annual outing on Thursday Sept. 1st.

The meeting then adjourned.

A working model of an improved Stone Hoisting and Setting Machine by Mr. G. Hunter, of Chicago. was set up for the inspection of the members at this meeting, and the improvement explained by Mr. Hunter.

Adjourned. JOHN W. WESTON, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

368TH. MEETING. SEPTEMBER 21, 1892:—The club met at 8 P. M., September 21, 1892. at the club rooms, President Johnson in the chair, and 26 members and 3 visitors present. The minutes of the 367th meeting were read and approved. The Executive Committee reported the doings of its 133rd and 134th meetings.

Upon motion it was decided that Mr. Eayrs, who while Vice-President of the Club, had resigned owing to removal from the city, be permitted to resume his membership by withdrawing his resignation and paying dues for the current year.

It was moved and carried that the chair appoint a special committee to consider ths question of future quarters.

The secretary was requested to notify the club that the subject of change of quarters would be brought up for action at the next meeting.

Prof. W. B. Potter then read the paper of the evening on "Water Supplies for Large Cities". The paper described the sources of our water supplies and showed the differences in mineral contents as affected by the

nature of the rocks which it met; in the Eastern cities where the supply passed over the granite rocks the mineral matter is small, while in the West, where limestones and clays are met with the amount is large. The different methods of filter were described and their uses shown. The question of boiler scales was noticed and the preventatives considered.

After mentioning the evil effects due to the presence of large amounts of lime the more important organic impurities were fully discussed.

The nature and character of the impurities found in the four classes of water supply, rain, surface ground and deep water, were dwelt on in detail.

A number of tables were exhibited showing the water supplies of the larger cities of the country.

Discussion followed by Messrs. Flad, Johnson, Seddon, Potter, Wheeler, Crosby and Russell.

Adjourned. ARTHUR THACHER, Secretary.

CIVIL ENGINEERS SOCIETY OF ST. PAUL.

OCTOBER 3, 1892:—Regular meeting of Society was held at 8:15 P. M., seven members present. President Woodman in the chair. Minutes of preceding meeting read and approved.

Secretary was instructed to ascertain from the Society representative on the Executive Committee of Engineering Societies, Columbian Exposition, the progress of said committees work and what further requirements our Society is expected to meet.

The question of a trip to Duluth by Twin-City Engineers was broached and President Woodman and Mr. Munster were chosen as a committee of arrangements.

William R. Mansel, John S. Beeston and Chas. A. Hunt were elected to membership.

Adjourned. C. L. ANNAM, Secretary.

WISCONSIN POLYTECHNIC SOCIETY.

19TH. MEETING, SEPTEMBER 12, 1892:—The Meeting was called to order at 8:30 by President Benzenberg, with 12 members present.

In the order of regular business, nothing of special importance transacted.

Motion made and carried to pay into the treasury of the Association of Engineering Societies $37.50.

Nothing reported by any of the special committees and no papers presented for reading.

General discussion on street pavements.

Mr. Benzenberg in opening the discussion remarked that one reason for the very bad condition of pavements in Milwaukee was that the cost of the original pavement was borne by the property owner, and as a consequence was almost invariably cheap, poorly made, and short lived. To make renewals and repairs the ward fund is drawn on, but this is generally too limited to carry out necessary work, and when not so is frequently made more or less useless or unavailable because of petitions from the ward to the council calling for cheap pavements. There should be a gen-

eral street fund to draw from so that work of a character suited to the traffic in any part of the City could be carried out in a manner to meet actual requirements. Brick pavements are generally unsatisfactory, even when special paving brick which prove equal in strength to granite, are used. Heavy traffic is very severe because of heavy concentrated loading, which splinters the brick at the edges. A heavy, well shod horse, in fly time, is still more severe and destructive.

Of all kinds of paving sheet asphalt is undoubtedly the best, as it has the advantage of being smooth, noiseless, easily repaired, and the expense of cleaning is much below that of any other pavement, while from a sanitary point of view, it is unsurpassed. A good pavement of this character should last all the way from 15 to 17 years. A good concrete foundation is all important with any kind of paving and when this is secured repairs and renewals are easily made. In Denver this pavement was put in at the rate of 1½ blocks per day. The material will become solid in half an hour, and the entire street is turned over to public traffic one day after being laid, even when the temperature of the atmosphere reaches 102 to 105 degrees in the shade.

Much of the sand stone pavement in Cleveland and Buffalo has been replaced by sheet asphalt with most pleasant and satisfactory results. Cedar block does not last more than 6 to 7 years at best. All kinds of block paving, whether of wood, stone, granite or block asphalt generally begins to fail at the interstices, material is split and crumbled by heavy loading and especially by horse shoe calks.

At 10:30 motion was made to adjourn. Carried.

M. A. Beck, Sec'y pro. tem.

20th. Meeting, October 10, 1892:—Fifteen members present. The president and Vice-presidents being absent, Mr. Johnson was chosen Chairman.

The treasurer reported a number of delinquent members. It was moved that time be given them until next meeting. Carried.

No paper being presented for reading, the discussion on "Wheel Records" was taken up. Mr. Barr explained the original object of his paper, from which the discussion on the evening when it was read diverged considerably. The object of the paper was the "Wheel Record" in itself, not the merits or demerits of the cast iron or steel-wheel. Much time and money is expended in keeping records, yet many of them fail as to their efficiency, both for want of accuracy and for lack of information bearing upon the nature of wheels. Therefore, his endeavors had been to establish a record which contains all necessary data for scientific and practical investigations and conclusions.

Mr. Johnson's question: Why is steel used so largely in Europe in preference to iron? again leads the discussion in the former channel. Mr. Barr offers two reasons: First, Europe, with the exception of Austria and Sweden, has practically no charcoal iron; secondly, in Europe public opinion is entirely in favor of steel, which is not the case in this country. Records on the Pennsylvania and St. Paul Railroads show a larger percentage of steel wheels broken than cast iron wheels, and close observers of the matter seem to entertain a revulsion rather than a preference to the steel wheel. Charcoal iron was used for wheels in the beginning of their manufacture in this country; at present a No. 5 iron is generally used. American cast iron as a rule is twenty per cent. stronger

than European cast iron. The discussion then verging into details of properties, manufacture and working of car wheels, was taken part in by Messrs. Johnson, Scholtka, Beck, Birkholz. In conclusion the chairman extended the thanks of the Society to Mr. Barr for the interesting remarks.

Mr. Johnson announces that the Electrical Club will have its annual banquet Thursday October 27th., and that the Club extends the invitation to the Society to participate. Upon Mr. Barr's motion, the thanks of the Society are expressed for the invitation and the Secretary instructed to send out notices to the members of the Society in regard to the matter, requesting an answer before Thursday, October 20th.

Adjourned. M. A. SCHINKE, Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.
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This Association, as a body, is not responsible for the subject matter of any Society or for statements or opinions of any of its members.

THE FINANCIAL STATUS OF THE ENGINEER.

Discussion before the Civil Engineers' Club of Cleveland.

[June 14, 1892. See March issue for original paper.]

After reading his annual address, Mr. Gobeille spoke as follows:

This subject has not been handled as it should have been for general discussion, for I had no thought that my address would come before you in this manner.

Let us suppose a case:—Two men are in sole possession of an island; one is strong, robust, athletic: the other not a deformed man, but weaker, and of a less stern disposition and feebler constitution. The strong man goes out to seek game: because of his strength he quickly secures a supply: the weaker brother is unable to secure any desirable food. What is the result? The weaker becomes the slave of the stronger. He prepares the food, cooks it and serves it to the stronger one, thereby insuring his own sustenance and perhaps his lease of life, for he is absolutely in the power of the strong man:—but game becomes scarce, the animals and birds learn that man is their enemy and they become more and more difficult to outrun or surprise, especially the desirable kinds. The weaker brother sees this. He invents and prepares a cross-bow, which, though of rude design, is adapted to hurl arrows for some distance from the point of dismissal. Now the tables are turned. With the cross-bow in his hands he goes out and procures game easily, and turning it towards the strong man, bids him prepare the food and be the slave; the socialistic idea is that all men should share equally, not in proportion to their strength or ingenuity, but simply in a *per capita* ratio, but is this true in fact?—not at all,—no-

thing is equally distributed in this world: the man of intellect, the man who invented the cross-bow and subjugated his stronger brother has but a short lease of kingship; he must need sleep, and while asleep the stronger brother possesses himself, not only of the prestige he formerly enjoyed, but the very thing, the product of the weaker brother's brain and hand, without which he would remain a slave and a servant. In a social system such as ours, it is necessary for the inventive and educated man to associate with himself the strong man of business as a partner, that he may be guarded while he sleeps: that he may be protected while his weapon is temporarily from his side or being repaired or from other causes useless for defense, and yet, strange anomaly, the man of education, the man of talent and research steadfastly refuses to associate with himself the man of business because it would be unprofessional, he prefers to go alone, and the result is precisely as I have indicated in my annual address. He goes alone to the disadvantage of himself and to the emolument of him who chooses to exploit him for his brains and its inventions. If the world were right, the learned man would be superior to the man of brawn and brass, but the world is *not right*; the millenium is still a long way off, and the only thing the engineer can do to protect the children of his fancy and of his long years of study, is to form an alliance with the very one who would steal them if he could.

To an audience like this, it is unnecessary to give a single example showing the truth of this parable; a hundred questions could be asked, the answer to which would be a proof and exemplification of its truth.

My complaint is that Engineers, in the legitimate practice of their profession, are notoriously underpaid, principally because their training unfits them for properly marketing what they have to sell.

Wm. H. Searles.

The paper under discussion has described tersely, a state of things well recognized among American engineers. The reasons for the modest rewards that usually fall to the engineer are not far to seek. They are to be found: *first*, in the training of his mind in the abstractions of mathematics and mechanical and physical science, which deal not at all with commercial values nor the art of money getting. Neither political economy nor personal profit forms any part of the curriculum he follows. His graduating thesis may deal exhaustively with the forces, external and internal, affecting an engineering design, and demonstrate carefully the true proportion of parts, yet give no hint as to the probable cost of the structure, nor as to its commercial value when completed.

While the accepted definition of engineering can hardly be improved upon, its common application is defective in that the money power of the world is not usually included among those forces which the en-

gineer is expected to control for the benefit of man. As the mere reading of the theory of Mechanics, and study of its algebraic formulas without a personal experience as to the nature and strength of materials do not make one a practical engineer, so both study and practice on these lines, without familiarity with the prices and relative values of materials and methods, and with the commercial value of finished designs, do not make the engineer an expert whose opinions as well as services will be in demand. The technical schools might well enlarge their courses so as to give the student some idea of market values, and prepare him for an intelligent discussion of those economies of construction that he will necessarily have to meet in practice.

Secondly: the small pecuniary rewards of the average engineer grow out of the nature of the engagements he makes, and the relation in which he stands to his employer. It is a general law of trade that he who serves on the profit side fares better than one who serves on the side of expense, though the latter man may be indispensable in his place. Thus, a salesman on the road, coming between a firm and its customers, may receive a large salary and commissions, and have all his expenses paid, while the book-keeper of the same firm, although occupying a position of great responsibility, must be content with a less salary, and pay all his own expenses. Again, one who serves another, either with hand or brain, usually receives less than one who pursues an independent career. Both these general laws operate against the young or assistant engineer. He works for a salary which is charged to expense account, and his services seldom bear an obvious relation to the profits that are hoped for in the enterprise on which he may be engaged. Hence there is tendency to reduce his pay to as low a figure as possible, especially when his duties follow a routine, although of skilled labor. It is probably on the same principle that the salaries of ministers of the gospel are as low as they are. Their labor, however profitable spiritually, shows no financial gain to their hearers, and is therefore regarded as a necessary expense, and is paid for usually at merely living rates.

Now, a lawyer is generally employed in protecting or enhancing the moneyed interests of his client: he identifies himself with, and takes direction of his clients' case as though he were the principal for the time being, and furthermore, being considered an expert in law, he is on all these accounts permitted to make his own charges, proportioned somewhat to the advantages gained through his services.

It is not often that an engineer is sustained, either by public opinion or private consent, in assuming a similar relation toward engineering work, at least in this country. The average Yankee considers himself a pretty good engineer himself: and rather enjoys directing his own enterprises, even though he must employ an engineer for certain de

tails. When however an engineer is well grounded in the principles of his profession, well versed in practical methods of handling materials and men, and has cool judgment in financial matters, a certain ability in the raising and expenditure of large sums of money so that profitable results follow his outlays, he may command practically, his own price for his services, and capitalists will defer to his judgment rather than trust their own in engineering enterprises. But engineers of this stamp do not usually depend on clients. They originate or adopt enterprises, the management of which they largely control, and invite the co-operation of capitalists with good success.

It would seem that in this direction the financial status of the engineer will be most attractive, and therefore toward this end should the engineer that aspires to wealth, strive, not neglecting study, nor failing to pick up ideas from practical mechanics, yet earnestly seeking to familiarize himself with business methods and business men so as to merit their confidence and approval. He should practice foresight and cultivate originality, and early learn to be a promoter of profitable enterprises in which he may command a share and so lay the basis of his fortune in life.

In case however his mind is so constituted that he cannot undertake the business side of engineering let him adopt the advice given in the paper before us, and ally himself with some bright and prudent business man who will supplement him in his efforts.

Another avenue to financial success is in the line of contracting. This is legitimately open to the engineer, but requires some special practical training. The engineer who is competent to build as well as design his work, who is a good manager as well as engineer covers the ground pretty thoroughly, and may establish a business of his own that ought to be lucrative.

But many engineers follow the profession for the pure love of it. They are fascinated with its many abstractions, and in its pursuit accept whatever compensations fall to their lot. To such a modest income is all that is likely to come. A genius may rise to prominence and for some novel achievement receive rich pecuniary reward, but this would be an exceptional case.

A consulting engineer is expected to be well up in the theory of the profession and in the facts of its history and to have a sound and unbiased judgment in regard to methods and projects. While his fees may seem to be for purely professional opinion and advice, yet his qualifications to render these acceptable must be based on long years of practical experience during the more active stages of his career, when he may have been receiving quite modest compensation though storing up a fund of information as a professional capital of inestimable value in his later years.

H. F. DUNHAM.

Your committee in asking me to join in the discussion of your President's address has in a word, offered a source of pleasure and a difficulty. It is a pleasure to be one of the numerous and widely scattered throng, who have expressed a keen appreciation of the address, and itis difficult where so much has been well said, to make additions worthy of your attention.

The reference to the "shrewd man" who thinks a bridge can be built or a cable laid, and forthwith proceeds by the help of other men to accomplish that which had been deemed hazardous or very difficult, seems a little unfortunate because speaking broadly, as I am sure your President would be understood to speak, the man who accomplishes so much, is usually a man with such breadth of mind and purpose, that he not only gives credit when due but takes a little pride and pleasure in giving it. There may be exceptions and there is a shrewdness which only merits censure, but it is more frequently associated with downright unfairness, as in garbling an engineer's estimate, or using a so-called engineer, or doing both at once, as in one instance that might be named, where the result was the disastrous investment of more than one hundred million dollars. Such conduct is exceptional, when compared with the great volume of legitimate business, and it ought to be referred to and regarded as we regard the dishonesty of a bank official.

Again, the shrewd man in the case cited, would not be apt to rush to our technical press with his borrowed plans and demonstrations. The man with a weak case, does not hasten with it to the supreme court; and the relation of such a court to its work is not very different from the relation of the technical press, and of many of our leading journals, to any such schemes when they have been submitted. No surer way of widely distributing credit, to whom credit is due, occurs to the writer, than that of putting detail drawings into the hands of journals that are so conscientiously edited, and generally read. A great amount of good has already been accomplished by those papers, in exposing weak and unfair schemes, and while their advertising columns are open to advertisements, it may be said without fear of contradiction, that their representatives are not.

A certain phase of the engineer's deficiency, as it presents itself to our President, would be favorably modified, if less praise, notoriety and wealth were thought to be ample. The engineer is simply one of the forces, through the action of which, results are brought about, and it seems that with him, as with many of nature's forces, the finest results are attained with least disturbance: as in the history of a country, when for a long interval there is nothing to record, we know the people have been prosperous.

It is to be regretted that the engineer should not get just compensation for his work, or all the credit that belongs to him, but in a country that is new like our own, where so much is done quickly and in a tumult, a perfect balancing of the scales is not to be expected. The writer cannot, however, agree with our President, as to the efforts the engineer should put forth to secure a living balance. "Now he is not in want, or his children begging." There are thousands who are grateful that so much can be, and has been said. Let the engineer, while he is an engineer, make such improvement in present conditions as he is able to, by giving closer attention to his methods and making the contrast between well and ill-designed work greater than it is now. Do not take him into trade through the avenue of another's brain and efforts, or put him in a position where he will have widely divided interests, or be in any sense principal and agent in one transaction, or be strongly tempted to surrender to himself the time and thought his present work or salary should command. It is through such double relations that standards are lowered and the conditions of which complaint is made, strengthened.

Nothing in this should be understood to limit the right or privilege of an engineer to engage in any honorable pursuit. His training as an engineer would be especially valuable if he were to give attention to railway management, the better class of contracting or to any one of a number of callings. The point is, that while doing the work of an engineer he should avoid relations foreign to that work and certain to divert his interest from it.

Let him invest, yes, if he have anything to invest, in securities that are safest and require least attention. He may economize but it should not be in books or opportunities for improvement. If he finds old age creeping on him unawares, and that his work is done before he thought it fairly commenced, let him be content with simple necessities and comforts.

Let him be thankful if he has been fortunate in avoiding danger to life, and fortunate in the construction of work that remains and is likely to remain. If his children do not receive the best possible education, let him be hopeful that they will not manifest an inherited tendency to manipulate railroads, as railroads are sometimes manipulated, or boom land, as land is often boomed.

MR. N. P. BOWLER.

Making money is a great deal like becoming a first-class musician, one must be born that way. A certain amount of brass, perhaps, may be useful, but there must be sagacity to lay hold of a good thing, whenever it is presented. To illustrate, I heard a horseman say, that there was a jockey that had become very wealthy, and he asked him how it was. "Well," he said, "the difference between me and the other

jockeys, is that I improve every opportunity and the others do not." An engineer associating himself with a business man, is doing a good thing. Associate with a man that can manage men and the business part, who will trust his engineer for the details so that he will not make any mistake in experimenting. A great many fortunes have been spent in experimenting. A man thinks he has something good, and after he has spent a great deal of time and money to perfect it, he finds it worthless. An engineer could have saved him all this trouble. I know of a great many experiments that have been going on in this City that have cost thousands of dollars, with no satisfactory results, and it is so everywhere. The men who make fortunes suddenly, are the exception, not the rule. It is not best to try to get rich that way. The proper way, is to supply our wants, to get a competency, by steady annual gains. Do not be in a hurry. There is much danger in haste to be rich. Good men are at a premium. I find the longer I am in business, the more difficult it is to get real first-class men that you can depend upon.

MR. LUDWIG HERMAN.

To illustrate the competition engineers have to meet, I will relate some incidents from my experience: About ten years ago I became acquainted with a young man, then lately arrived from Europe and employed by a large eastern firm as draftsman. In conversation about the engineering school from which he graduated, he related the parting remarks made by the principal of the school when he was bidding him good by before starting for this country. They were: "All you have learned here will be useful to you in America, but the most important quality in that country for achieving success is *brass*." My friend certainly profited by this advice; he backed a little knowledge with a great deal of brass and prospered.

The idea that anybody without any previous training is capable of doing his own engineering is very often met with in this country, the woods are full of that class of geniuses; only to-day I had the satisfaction of having two of them admit to me that their work, though quite expensive, was worthless. I can probably put some light on this. The reason that engineers in Europe have so high a standing is their general competence. A young man after leaving school over there, works for years in subordinate positions under superiors with established reputations, and is not entrusted with any important work until he becomes quite old and experienced. Here we often find boys without experience or practical training, put in charge of extensive and even hazardous work, through social, financial and other influences.

MR. WM. T. BLUNT.

I do not know that I have anything of importance to add in regard

to the matter: but there are two points made which may perhaps be emphasized by further mention.

One is that the engineer's services are always shown on the expense side of the account. The corporation or party who employs the engineer seldom appreciates what his services really mean, there being no way to determine actually what money benefit has been derived from those services. Usually, the compensation for professional services is entirely out of proportion to the increase of income or of saving due to those services. But the increase does not *show* on the income side while the engineer's services *do* show on the expense side. In Government work, where my time has largely been spent, the compensation is limited to a certain figure and whether the man's worth be great or little, he can never receive more.

The second point to be emphasized is that the education of the engineer is too largely technical. He is taught rather to shun the business or commercial side of life, and that he is on a plane a little above that and where he must deal with the purely technical questions, leaving the money making to others, after he has given them the means, and for a mere pittance of the portion which should fall to his share. Being imbued with this idea from the outset, it usually follows him through life, making a technical slave, loyal to his profession, too proud to be a money getter, but satisfied to struggle on paving the way for others to become rich while he "hunts another job."

Mr. W. R. Warner.

I may take the unpopular side of the subject, but it is my firm conviction that as far as salaries and fees and wages go, the engineer gets his share. He sells the use of his talents for their market value, and no one has reason to expect more.

I once heard of a young engineer who received a fair salary, but who applied to his employer for an increase. The response made a point that seemed to me an important one. The employer said, "as we measure your talents and compare them with those of others in our employ, and others whom we know, we are paying you your market value. We may, however, be mistaken in judging your market rate. If you can establish a higher rate either here or elsewhere, then you will get it. You may in all good faith, if it seems best to you, secure another position and see if you can raise the market rate for the use of your talents, and six months or a year hence come back to us and we will pay your market rate at that time." This was a new phase of the question to the young engineer and he said he would think of it. The next day he said to his employer, "I have decided what to do." "Well, what is it?" "To endeavor to raise my market value right here." Now, the result was that in six months that young man's salary was raised 25 per cent., an unusually good advance, but

still his "market rate." We each of us by the study of men and books and things are establishing for our talents a market value. Sometimes, by force of circumstances, a man for a little while may get more than his market rate, sometimes less. If he gets more it will be reduced, if less, it will be raised.

Why does the expert engineer in the city hall get only fourteen hundred and forty dollars per annum instead of three thousand? We can not think that for philanthropic reasons he allows the city the use of his talents for less than their market value. What then is the trouble with engineers? There must be something wrong. I think it is because our education is too narrow. We very often run up against our limitations, and sometimes see limitations in others.

Now, the science of engineering and its kindred studies ought to broaden a man, and will if he will let it, for it should bring him in contact with minds stronger than his and lead him to observe facts as well as figures, and to measure men as well as angles. The successful engineer, as well as the great General, has learned to manage men and lead them with such tact that they are glad to follow. It is not enough that he lead the large class armed with the pick and shovel. He must also lead the capitalist and the promoter of great engineering schemes. In other words, a knowledge of mathematics alone will never make a successful engineer. It must be coupled with executive ability, gained by close study of men and keen sighted observation. The ability to lead others is one of the greatest secrets of success in all walks of life.

Let us take for example two clerks in Taylor's store. They may be equally bright and educated. They may each have departments equally desirable, but at the close of the year's business one has sold 50 per cent. more than the other. Why is it? Not because he had a better education. No, but because what little education he did have enabled him to meet his customers in such a manner that they were glad to visit his counter, and when they came to price cheap silks, he could sell them good silks. Did it affect his financial status? Yes, it soon made him a department manager and later qualified him to enter into business for himself.

I remember a conversation I once had with a member of this Club five or six years ago. He had just come in from an engineering trip on which he had made the surveys for a railroad. I said to him, "Now, you know all about that road, more than any one else. You know all the cuts and fills and just how it ought to be laid out. You have a great advantage over any contractor. Why don't you say to the capitalists who employed you, "I will build that road for so many hundred thousand dollars and then go ahead and make your fortune, instead of being content with your paltry fee and allowing a smaller

man to make the fortune?" He replied: "It is not professional and I will not do it," and calling my attention to a physician in the room asked if it would be professional and right for that physician, when called to visit a sick person to say, "I understand your case thoroughly and I can restore you to health in a short time. I will do it for one hundred dollars." Of course, I said "No, but it is not a parallel case." He thought otherwise, and allowed a man of lesser education and talents to construct the road and make the fortune. Is the engineer properly paid? Yes, he is paid for the work he does. If that work is the solution of a formula or a computation giving the strength of a beam, he gets for it a proper fee. If that work is the originating and carrying to a successful issue of great engineering schemes by which nature's deepest problems are solved, and the commerce of the world increased and the civilization advanced, then not only honor but wealth flows to him.

Mr. Hosea Paul.

I have asked the privilege of continuing and partially to review the discussion which has taken place in regard to "The Financial Status of the Engineer" aiming rather to consider the phases of the question as then brought out rather than to present the subject in its entirety.

As to the points advanced I shall not say anything in regard to the propriety of adopting measures to keep out incompetent and imperfectly trained aspirants for engineering honors, nor shall I discuss the relations between capital and labor, or other problems of political economy.

The suggestion has been made in the course of this discussion that raises a question, like this: Must an engineer be content as best he may with a nominal rate of compensation avowedly less than that awarded to men of no greater skill in callings of no greater dignity or usefulness, and depend for more substantial rewards on the taking advantage of the opportunities that so often present themselves to embark in collateral pursuits such as his training and experience qualifies him for, contracting, railway management, real estate, speculation, manufacturing, mining or exploiting and promoting inventions and projects?

That these are pursuits that an engineer may look forward to we would not question. They are the great avenues that lead to wealth even though success is less easy and risk much greater than pictured by popular fancy.

But however, natural and easy the transition, by becoming a contractor, or a manufacturer, a speculator, a promoter or a boomer, just so far as he adopts this new calling, and so long as he remains in it, he for such time ceases to be an engineer *per se*.

He may indeed return to it, and he may still find his engineering

knowledge and experience of value, but for the time he has in great measure lost his identity.

It may be good advice to give an engineer whose meagre financial returns are disappointing to tell him to engage in another business, and it may be more easy for him to become a contractor than a merchant, but all this is beside the question, which relates or should relate to its compensation that the engineer receives as such from day to day or for a particular service rather than how well it may serve him as a ladder to reach something else.

In the first place it is a mistake to assume that engineering is a peculiarly favored profession as regards entering new fields of activity and profit. The peasant soldier under Napoleon might become a marshal of France. The humble clerk in the village store may hope to become a great merchant or a senator. The omnipresent lawyer has always the resource and virtual monopoly of political preferment, and in railway and in manufacturing affairs, he is at least not far behind the engineer. Others than engineers may become managers, promoters, organizers, leaders of men and affairs. In the possibility of obtaining such great prizes he has certainly no preference.

Much of this talk of future possible opportunities ignores the fact that the more a man is paid as he goes along the better able will he be to take advantage of such opportunities when they arise. If he is kept down to the subsistence point new careers, however desirable, are practically closed to him. The tide that comes to every man, may reach its flood, but his craft is not ready. He must plod along as before.

A parallel has been drawn between the priest or clergyman and the engineer as that of callings where men labor for the love of it and the good it may do, rather than for the substantial reward of good hard cash. There is however this difference. The clergyman or priest has two things that an engineer has not. First he may get his education and even his support during college life without cost; second, whatever his salary his social standing is an assured one. Though near beggary he may sup with the king.

And whatever may be the value of these things, there is no doubt they are charged up and that they have to be paid for on the installment plan by a regular deduction from the normal salary.

But the training of an engineer is an expensive one in itself, vastly more so than that required for a literary, legal or theological career. Laboratories and instruments cost more than books. He is not supported or aided as a student by an organized system of charity.

Once launched into professional practice, his clientage is rigorous and exacting. Definite and successful results are insisted upon and failure is not excused because precedents were followed. He can not

depend upon the book, the gathered wisdom of by gone days, but is continually asked to distrust them--to do what no one else has done. He must be abreast with discovery, invention, mode and process, and though much is expected, and no charity extended for error, his share of the credit of success is but scant, and his pay but that of a routine worker.

His fees are largely contingent, but usually in a way that he takes all the risks of failure for which he may not always be responsible without proportion or adequate share in case of success.

For all his careful training, conscientious service, and exacting requirements we are told again that he may not expect more than a fair market price. That the world, in the long run, will generally pay a man what he is worth. All this is a truism, but what makes a fair market price? Obviously when those who buy and sell meet freely and make their exchanges. But if one party is under restraint, is negligent or indifferent he is sure to be the sufferer. Each must attend carefully to his interests; in a sense the other party if not an enemy will require watching.

And it seems to me that the engineering profession has been negligent and careless in this very matter. They have accepted what the public chose to give them, to depend on its generosity, rather than demanding justice, and as a matter of course, asking little, it has been with such modesty they have got even less.

The remedy it seems to me is the better realization among engineers of the value of their work to the world, that to their hands are committed some of the greatest problems of civilization, that no career is greater or more deserving. If this is true, and who can gainsay it, have they not a right to homes and flowers, to books and music, to the advantages of travel, to sights, of sea and mountain, and of historic renown, to give to their children education and advantage? If so they must have good pay and they ought to have it as they go along, as they earn it independently of the chance or the possibility, of securing more pay or profit in other lines however obvious or related.

Now the engineer is not a poet or a philosopher, a dreamer of mysteries, a delver in the deep mysteries of nature, a man above the world, and among the shining stars; not of the men whose compensation cannot be measured in money, and who ordinarily have little hold on the public purse, nor is he yet of the type, of the great body of the worlds workers, who by trade unionism, can stop the wheels of commerce, who can in a measure if they will clutch civilization by the throat and extort their terms. He belongs to neither of these extremes.

He is not a mere idealist, nor yet a walking delegate. But as a self respecting citizen, pursuing a high and honorable calling, in touch

with, and a factor in the great currents of activity and achievement he may fairly ask for his own. He may of right have his say when the question of market price comes up.

STONY BROOK IMPROVEMENT.

By Henry H. Carter, Member, Boston Society of Civil Engineers.

[Read December 16, 1891.]

Stony Brook rises in Muddy Pond in the West Roxbury district of Boston, about one-fourth of a mile west of the Hyde Park line. After flowing in a southeasterly direction through the town of Hyde Park, it turns and runs in a general northerly direction through West Roxbury, Jamaica Plain, Roxbury and the City Proper for a distance of about seven miles to the outlet in Back Bay Park. The brook formerly emptied into the Charles River in what was known as the "full basin." The lower mile of the brook was a tidal stream which followed a tortuous course through the salt marshes in the vicinity, extending from a small tidal bay in the vicinity of Elmwood street across Tremont street to the Boston and Providence R. R., thence to the full basin.

The water-shed of the brook comprises a total area of about 13.92 square miles, or 8,900 acres; of which amount 690 acres are meadow land liable to flooding. This water-shed is divided into several subsidiary parts, tributary to the various branches of the brook. These various drainage areas vary in extent from 1,800 to 140 acres. The topography of the various water-sheds of the different branches of the brook is very varied. Some of these areas are steep and have a very quick water-shed; others are largely meadow and flat wooded land, making a slow water-shed. In general it may be said that the water-shed is of average character, and that in its original state the water-shed and the brook presented no unusual feature.

The rapid growth of the city and the consequent improvement of land for building purposes has greatly modified the original state of the water-shed. Trees and bushes have been cut down, culverts have been enlarged, houses and streets have been built, and many changes have taken place, so that what was once a slow water-shed has been transformed into a quick one. This transformation of the character of the water-shed is continually going on, and the time is not far distant when a large proportion of the rain which falls on the surface will be carried into the brook, and flow off almost as quickly as it falls.

In its natural state, years ago, the brook ran through land which generally was but little elevated above the bed of the brook. The

flooding of this land, owing to the rough character of the water-shed, which was covered with trees and bushes which retarded the flow of the surface water, and lessened the rate at which the water reached the brook, only occurred in time of very heavy rain and spring freshets, and did no particular damage, as the meadows in the vicinity of the brook were but little built upon. As the value of the land increased, and the brook was encroached on by buildings and manufactories, the flooding of cellars and the consequent damage to property became so great, that it became necessary to take steps to improve the brook channel.

The first step towards the improvement of the brook was taken by the town of Roxbury in 1851. The Board of Health having represented that the brook from Ruggles street to Pynchon street, along the tidal bay, was in a state of nuisance, a scheme was proposed to cover the brook channel and fill in the land to make a public park. The brook was accordingly covered in east of Tremont street, through what is now known as Culvert street, and the land filled in. The expense was so great that the filled land was sold instead of being devoted to park purposes.

The next step taken was by the town of West Roxbury in 1855 in obtaining the passage of an act of Legislature (chap. 308, 1855) authorizing the town to divert the course and improve the channel of the brook in West Roxbury and Roxbury. No work was done under this act, however, except to make a survey of the brook throughout its whole course.

In 1865, the brook again became a nuisance in Roxbury, and under an act of Legislature the City of Roxbury diverted the brook channel below Tremont street, and covered it in along a channel built through Rogers avenue as far as the full basin. In 1866 and 1867, the work was continued by walling and covering in the brook from Vernon street to the car stables at the junction of Pynchon and Tremont streets.

The brook was at this time walled or covered in from the car stables at the corner of Pynchon and Tremont streets to the full basin. The cross-section of the channel is somewhat varied, but the brook was considered at that time as improved between these two points.

In West Roxbury, the damage arising from floods and freshets was becoming so frequent and severe that in 1868 an act was passed by the legislature to allow the town of West Roxbury and the city of Boston to take land for the improvement of the brook, and assess one-half of the betterments. The act not being satisfactory to the city authorities, no work was done under it. In 1870, the West Roxbury authorities gave up the attempt to co-operate with the Boston authorities, and an act was passed providing for a commission to carry out the old act of 1868. $25,000 was appropriated by the town, and the land was taken

from the Boston line to Williams street. In 1873, other takings were made, and the brook located from the Hyde Park to the Boston line. The channel was widened, deepened, and straightened, and the fall equalized. This plan of improvement was objected to by the Boston Belting Company as one likely to bring destructive floods on their property, as it would precipitate the water upon their factory without adequate provision being made to take care of it below Tremont street.

In 1873, West Roxbury was annexed to Boston, and an effort was at once made to have the brook improvement completed from the car stables on Pynchon street to the West Roxbury line, so that the benefit of the outlay already made in West Roxbury could be realized. In 1874, an act was passed empowering the city to improve the brook for surface drainage.

In 1875, a contract was made to build a double stone culvert under Washington street and the B. & P. R. R. at Forest Hills. In 1876, the Street Commissioners of Boston were requested to consider and report upon the matter of improving the brook from the car stables on Pynchon street to Forest Hills. In 1877, the Commissioners recommended that the brook be improved in accordance with a plan which was submitted by the Superintendent of Sewers, at an estimated cost of $53,000 for land and building damages, and $80,000 for the construction of a channel between the car stables and Hyde Park avenue. By this time the state of the brook was such in West Roxbury that the Board of Health reported upward of 100 dwellings which were subject to inundation at every considerable flood, and thus rendered unfit for habitation. A joint special committee was appointed in 1878 to take charge of the improvement of the brook under the acts of 1874, with authority to remove obstructions, alter the course and deepen the channel of the brook, and to take land required for the improvement.

Before work could be commenced, the Boston Belting Company notified the City that an injunction would be applied for, if work was commenced, as they considered that their right under the act of 1874 would be infringed. This opposition delayed work on the brook until 1880, when a satisfactory agreement having been entered into with the Belting Company, the required lands extending from the Car Stables to the Old West Roxbury line were taken.

Work was begun in July, 1880, at the junction of Tremont and Pynchon streets, and a double brick channel 10 ft. high by 7 ft. wide was constructed as far as the junction of Centre and Pynchon streets. This work cost $102,000, and lasted until February, 1881. Operations were commenced in March of 1881 on the open walled channel between Centre street and the West Roxbury line, and were continued until

1884, at which time the channel with the various street culverts was completed at a cost of $330,000. Including the appropriation made by the town of West Roxbury, the expenditure for the brook construction footed up the sum of $406,000.

On the completion of the work in 1884, the joint special committee made a report, concluding with congratulatory paragraphs on the benefits which would accrue from the completion of the enterprise, and on the immunity from floods which the abutters on the brook would henceforth enjoy.

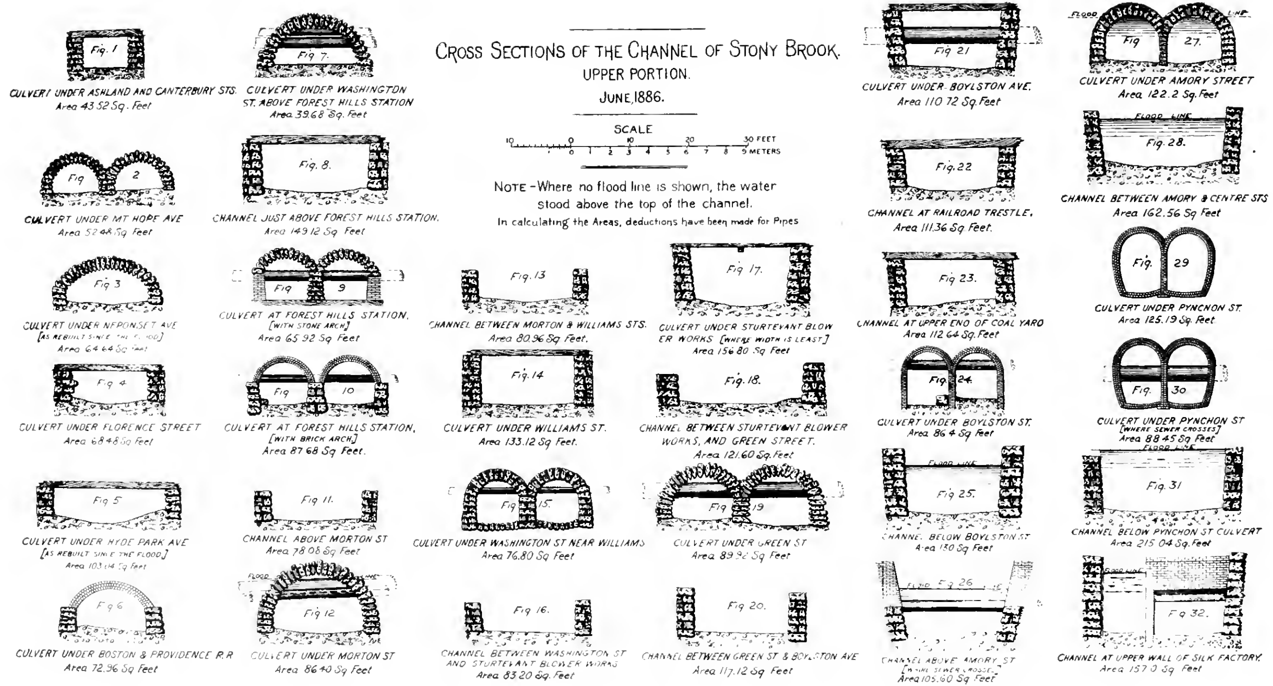
From the above description of the method adopted to improve Stony Brook from 1851 to 1884, it is seen that the course pursued was:

First, to wall and cover in the brook from the full basin up to the junction of Tremont and Pynchon streets in a rough rubblestone channel;

Secondly, when the flooding of meadow land in Jamaica Plain and West Roxbury became a nuisance, to widen, straighten and deepen and wall in the brook from Pynchon street up to Hyde Park avenue, in West Roxbury.

Unfortunately, both the so-called improvements seem to have been made in a haphazard manner, without due investigation of the problem.

The areas of the covered channels vary from 75.52 sq. ft. to 160 sq. ft. As a natural consequence of the way in which these channels were constructed, they soon got out of repair, and were obstructed by the caving in of walls and roofs. From the appearance of the cross-sections, it would seem that the City authorities did not have the benefit of competent engineering advice. In regard to the so-called improvement carried out at an expense of $330,000 from 1880 to 1884, this improvement consisted of a double-covered channel from the junction of Pynchon and Tremont streets to the corner of Pynchon and Centre streets, a distance of about 1,770 feet, and a walled open channel from this last point to Hyde Park avenue, a distance of about 3 miles, together with the necessary culverts under streets which were crossed. There is no record or data in any report to show what amount of water the engineer was endeavoring to provide for; no calculation of the probable amount of water to be handled or calculation of a proper sized channel to convey it. As a matter of fact, the open channel will convey about 350 cu. ft. per second without overflowing its walls; and as will be shown later on, the amount of water to be handled in the future will be about 2,000 feet, thus showing that the calculations if any were made, were considerably at fault. Several of the culverts and parts of the channel on the lower part of the stream which can be seen on the appended sketches are unable to carry over 350 cu. ft per second, except under considerable head; and the carrying out of the upper part of the so-caller improvement and making it capable of carry-


CROSS SECTIONS OF THE CHANNEL OF STONY BROOK.
UPPER PORTION.
JUNE, 1886.
SCALE
10 0 10 20 30 FEET
0 1 2 3 4 5 6 7 8 9 METERS
NOTE - Where no flood line is shown, the water stood above the top of the channel.
In calculating the Areas, deductions have been made for Pipes
Fig. 1
CULVERT UNDER ASHLAND AND CANTERBURY STS.
Area 43.52 Sq. Feet
Fig 2
CULVERT UNDER MT HOPE AVE
Area 52.48 Sq Feet
Fig 3
CULVERT UNDER NEPONSET AVE
[AS REBUILT SINCE THE FLOOD]
Area 64.64 Sq Feet
Fig 4
CULVERT UNDER FLORENCE STREET
Area 68.48 Sq Feet
Fig 5
CULVERT UNDER HYDE PARK AVE
[AS REBUILT SINCE THE FLOOD]
Area 103.04 Sq Feet
Fig 6
CULVERT UNDER BOSTON & PROVIDENCE R.R.
Area 72.96 Sq Feet
Fig 7.
CULVERT UNDER WASHINGTON ST. ABOVE FOREST HILLS STATION
Area 39.68 Sq. Feet
Fig. 8.
CHANNEL JUST ABOVE FOREST HILLS STATION.
Area 149.12 Sq Feet
Fig 9
CULVERT AT FOREST HILLS STATION.
[WITH STONE ARCH]
Area 65.92 Sq Feet
Fig 10
CULVERT AT FOREST HILLS STATION.
[WITH BRICK ARCH]
Area 87.68 Sq Feet.
Fig 11.
CHANNEL ABOVE MORTON ST
Area 78.08 Sq Feet
FLOOD LINE
Fig 12
CULVERT UNDER MORTON ST
Area 86.40 Sq Feet
Fig. 13
CHANNEL BETWEEN MORTON & WILLIAMS STS.
Area 80.96 Sq Feet.
Fig. 14
CULVERT UNDER WILLIAMS ST.
Area 133.12 Sq Feet.
Fig 15.
CULVERT UNDER WASHINGTON ST NEAR WILLIAMS
Area 76.80 Sq Feet
Fig 16.
CHANNEL BETWEEN WASHINGTON ST AND STURTEVANT BLOWER WORKS
Area 83.20 Sq. Feet
Fig 17.
CULVERT UNDER STURTEVANT BLOWER WORKS [WHERE WIDTH IS LEAST]
Area 156.80 Sq Feet
Fig. 18.
CHANNEL BETWEEN STURTEVANT BLOWER WORKS, AND GREEN STREET.
Area 121.60 Sq. Feet
Fig 19
CULVERT UNDER GREEN ST
Area 89.92 Sq Feet
Fig 20.
CHANNEL BETWEEN GREEN ST & BOYLSTON AVE
Area 117.12 Sq Feet
Fig 21
CULVERT UNDER BOYLSTON AVE.
Area 110.72 Sq. Feet
Fig. 22
CHANNEL AT RAILROAD TRESTLE.
Area 111.36 Sq Feet.
Fig 23.
CHANNEL AT UPPER END OF COAL YARD
Area 112.64 Sq. Feet
Fig 24.
CULVERT UNDER BOYLSTON ST.
Area 86.4 Sq Feet
FLOOD LINE
Fig 25.
CHANNEL BELOW BOYLSTON ST
Area 130 Sq Feet
FLOOD LINE
Fig 26
CHANNEL ABOVE AMORY ST
[WHERE SEWER CROSSES]
Area 105.60 Sq Feet
FLOOD LINE
Fig 27.
CULVERT UNDER AMORY STREET
Area 122.2 Sq. Feet
FLOOD LINE
Fig. 28.
CHANNEL BETWEEN AMORY & CENTRE STS
Area 162.56 Sq Feet
Fig. 29
CULVERT UNDER PYNCHON ST.
Area 125.19 Sq. Feet
Fig. 30
CULVERT UNDER PYNCHON ST
[WHERE SEWER CROSSES]
Area 88.45 Sq Feet
FLOOD LINE
Fig. 31
CHANNEL BELOW PYNCHON ST CULVERT
Area 215.04 Sq. Feet
FLOOD LINE
Fig 32.
CHANNEL AT UPPER WALL OF SILK FACTORY.
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ing a large volume of water and leaving the lower part in its existing condition, was a very serious blunder, and one that has cost the City of Boston thousands of dollars.

The authorities of the Belting Co. apparently knew more about engineering than the City authorities in charge of the improvement, as they entered a protest against the work.

The storm of Febuary 10 to 12, 1886, brought it forcibly to the attention of the citizens of Boston that there was something wrong with the Stony Brook Improvement. Rain began to fall at 7:45 A. M. on the 10th, and continued falling until 2:45 P. M. of the 13th. The total precipitation, as deduced from the records, was 5.86 inches; to which must be added two inches for melting snow.

The new channel proved inadequate to convey this amount of water, and all the meadows about the main and tributary branches of the brook were flooded, and water was reported as entering 191 dwellings in West Roxbury. Although the new channel was incapable of providing for all of the water, it carried a much larger quantity than it could before its improvement, and very much more than the channel below the junction of Tremont and Pynchon streets could care for, although it ran under a head, and the water stood several feet above the top of the channel at its upper end. The water rose and overflowed about 63 acres of thickly settled low territory in the vicinity of Elmwood street, flooding cellars, yards and streets. 1437 buildings occupied by 3,090 families were affected by the overflow. Observations made at the time showed that about 500 cu. ft. per second flowed in the brook.

The effects of this flood, which are still fresh in the public mind, were such as to lead to an immediate investigation of the cause of the trouble and the remedy to be applied. Three eminent engineers (members of this Society) Messrs. Clark, Herschel and Francis, were appointed by the Mayor to investigate the cause of the disaster, and submitted an elaborate report on the subject. (Doc. 159 of 1886)

The report of the Commission deals with,

1st. The problem of the amount of water to be provided for; and
2nd. The way to get rid of it.

The report of the Commission showed that it was necessary to provide for the maximum flow from 12.727 square miles of watershed due to the precipitation upon it, less the amount evaporated or absorbed by vegetation, or temporarily lost by absorption. In order to get at the amount of water to be provided for, the Commissioners cited six different formulas for calculating the amount of water theoretically; and also examined the problem from an entirely practical point of view. The formulas were:

1st. The Dickens formula which gave 5,559 cu. ft. as a flood discharging on the Stony Brook watershed.

2nd.	The	Dredge	formula	5,011	cu. ft. disch.
3rd.	"	O'Connell	"	1,886	do.
4th.	"	Craig	"	5,313	do.
5th.	"	Fanning	"	1,666	do.
6th.	"	Burkli-Ziegler	"	500	do.

These results are very discordant, and with one exception I do not consider them worth considering. The exception is the Burkli-Ziegler formula, which in my opinion is a remarkable one, and entitled to consideration.

The formula is,

$$Q = C\ R\ \sqrt[4]{\frac{S}{A}}$$

in which Q = cu. ft. per second.

C is a coefficient ranging from .31 to .75, depending on the nature of the surface. the higher coefficient being for districts with paved streets and roofs, the lower for rural sections of suburbs.

R equals average intensity of rain during period of heaviest fall in cu. ft. per second per acre: assumed, one half inch of rain per hour, or .504 cu. ft. per second in the calculations of the Commission.

S equals general grade of area per thousand feet, assumed for Stony Brook water-shed at 20.

A equals area of water-shed in acres, assumed for Stony Brook at 8,145 acres.

As previously mentioned, this formula when used for Stony Brook, calling the water-shed a suburban one and using the intensity of rain as one half inch of rain per hour, gave the result of 500 cu. ft. per second; which agrees with the actual observations of the amount of water which flowed in the brook at that flood. I believe this formula is capable of giving the result which the Commission finally arrived at by other methods, which provided for 2,000 cu. ft. per second; for if we alter the coifficient C to the one which the Burkli-Ziegler formula prescribes for paved and built-up areas, and change the intensity of rain to one inch per hour, which is the amount generally calculated on in this vicinity, we shall get a result approximating the quantities which the Commission arrived at by more practical methods. The report of the Commission of the amount of rainfall concludes as follows:

"On a mature consideration of all the conditions that occur to us, but without undertaking to provide for remote possibilities, we are of the opinion that a rainfall of 12 inches in 24 hours or the equivalent in rain, melted snow and ice should be provided for. The proportion of this that would flow off in the stream during the same time depends

largely upon the condition of the valley. In its present condition, probably not more than $\frac{1}{4}$ of the whole amount would reach the lower end of the valley; the large part of the remainder would be held back in the meadows and other low places to flow off gradually, as in the flood of February, 1886. Improvements will no doubt be made at an early date to prevent this, and of course a proportionately larger quantity will flow off in a given time. As the land becomes occupied by buildings and assumes an urban character, with houses close together and with paved streets, or even if the surface be laid out as a park with driveways and subsoil drains, a still larger proportion will flow off in a given time, until ultimately, if the City continues to grow in that direction as it has done, we estimate that in a rainfall such as we are considering, the maximum flow in the stream would be about $\frac{3}{4}$ of the rainfall during the same length of time.

"The flow in the stream would not be synchronous with the rainfall, but later, and as the storm progressed, the tendency would be for the rate of flow to approach the rate of the rainfall, and if the rain continued to fall indefinitely at a uniform rate, the flow in the stream and rainfall would after a certain interval be nearly the same.

"Twelve inches of rain in 24 hours on the water-shed of Stony Brook is at the rate of 4,101 cu. ft. per second. In the present condition of the stream above the Pynchon street culvert, we are of opinion that the maximum flood at that point would correspond to about $\frac{1}{4}$ of that rate, say, about 1,000 cu. ft. per second; and when the channels of Stony Brook and its tributaries above the culvert are improved to an extent to relieve the meadows from being flooded, we estimate that the maximum flow in the stream would be about $\frac{1}{2}$ the rate of the rainfall, or say, 2,000 cu. ft. per second; and ultimately, when the valley is all closely built upon, the rate of flow would be equal to $\frac{3}{4}$ of the rainfall, or about 3,000 cu. ft. per second. It is proper to explain at this point that the commission have designed a channel to take 2,000 cu. ft. per second; whereas, their report gives 3,000 cu. ft. per second as the maximum flow in Stony Brook. It is, however, possible in the future when the valley and water-shed has been so built up that the flow amounts to 3,000 cu. ft. per second, to construct a tunnel leading to the Neponset River which will provide for a flow of 1,000 cu. ft. per second.

The amount of water to be provided for having been determined, it remained to design a channel of a size and shape sufficient to carry it off. The elements which enter into this design are:

1st. The inclination or hydraulic gradient of the channel;

2nd. Its shape and size;

3rd. Its mode of construction;

4th. Its location.

In determining the hydraulic gradient of the proposed conduit, the comparative elevation of the surface of the water at the upper and lower ends must be considered. The elevation of the lower end is that of the water in the Back Bay Park, which is connected with Charles River. As the river is a tidal stream and as it is not safe to depend on being able to use the Back Bay Park as a storm reservoir, the height to which the tide in Boston Harbor may rise must be considered.

The average rise is......................10.44
Frequently, the rise is.................12.50

During 18 years, the tide rose above

Grade 13	41	times
" 13.50	19	"
" 14	8	"
" 14.5	3	"
" 15	1	"
" 15.5	1	"

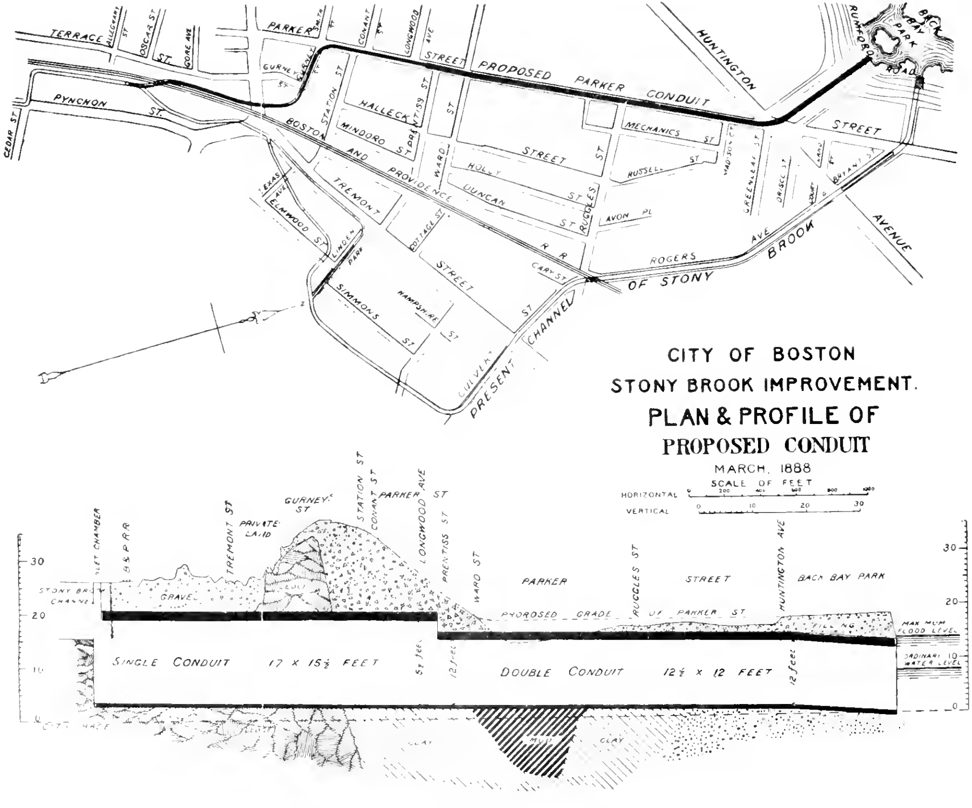
The chance of a freshet occuring at the same time as a 15-foot tide is so slight that it was not considered.

Grade 13 was adopted as the height at which it would be safe to assume the tide on the occurrence of a freshet, and as one foot fall was allowed for the inclination between the outlet of the conduit with Park Pond and the River, it gives us Grade 14 as the elevation of the water at the lower end of the conduit. At the upper end of the proposed conduit, it was deemed inexpedient to allow the water to rise higher than Grade 19. We thus have a difference in elevation of 5 feet, and a length of conduit of 3,911 feet, from which we can calculate the size necessary to carry 2,000 cu. ft. of water per second.

The grade of Parker street was such that a single channel of the required dimensions would involve raising the grade of the street several feet, so that a single channel was recommended from the inlet chamber to the corner of Longwood avenue and Parker street, and a double channel from this point to the outlet in the Back Bay Park.

The report of the Commission (City Document 159, 1886) is a very able and interesting one, and contains much data bearing on rainfall and the question of the prevention of floods.

The report of the Commission was made to the Mayor in July, 1886, and was submitted with an approving message to the Council in August. The report was accepted, and the sum of $600,000 was appropriated to carry out that section of the work between the junction of Pynchon and Tremont streets and the Back Bay Park. The carrying out of this work was put in the hands of Mr. Seth Perkins, the Superintendent of Sewers at that time, and the writer was appointed Chief Engineer. Mr. Sidney Smith, member of this Society, was Engineer in


CITY OF BOSTON
STONY BROOK IMPROVEMENT.
PLAN & PROFILE OF
PROPOSED CONDUIT
MARCH, 1888
SCALE OF FEET
HORIZONTAL
VERTICAL
PROPOSED PARKER CONDUIT
TERRACE
PYNCHON ST.
CEDAR ST
OSCAR ST
GORE AVE
PARKER
GURNEY ST
STATION ST
CONANT
LONGWOOD AVE
STREET
HUNTINGTON
BACK BAY PARK
RUMFORD ROAD
HALLECK
MINDORO ST
PRENTISS ST
WARD ST
BOSTON AND PROVIDENCE R R
MECHANICS ST
RUSSELL ST
HOLLY
DUNCAN ST
RUGGLES ST
AVON PL
GREENLEAF ST
DRISCOLL ST
BRYANT ST
AVENUE
TREMONT STREET
TEXAS AVE
ELMWOOD ST
LINDEN PARK
COTTAGE ST
CARY ST
ROGERS AVE
BROOK
OF STONY
CHANNEL
PRESENT
CULVERT
SIMMONS ST
HAMPSHIRE ST
INLET CHAMBER
B & P R R
TREMONT ST
PRIVATE LAND
GURNEY ST
STATION ST
CONANT ST
PARKER ST
LONGWOOD AVE
PRENTISS ST
WARD ST
PARKER
RUGGLES ST
STREET
HUNTINGTON AVE
BACK BAY PARK
STONY BROOK CHANNEL
GRAVEL
PROPOSED GRADE OF PARKER ST
FILLING
MAXIMUM FLOOD LEVEL
ORDINARY WATER LEVEL
SINGLE CONDUIT 17 x 15½ FEET
DOUBLE CONDUIT 12½ x 12 FEET
5½ feet
12 feet
12 feet
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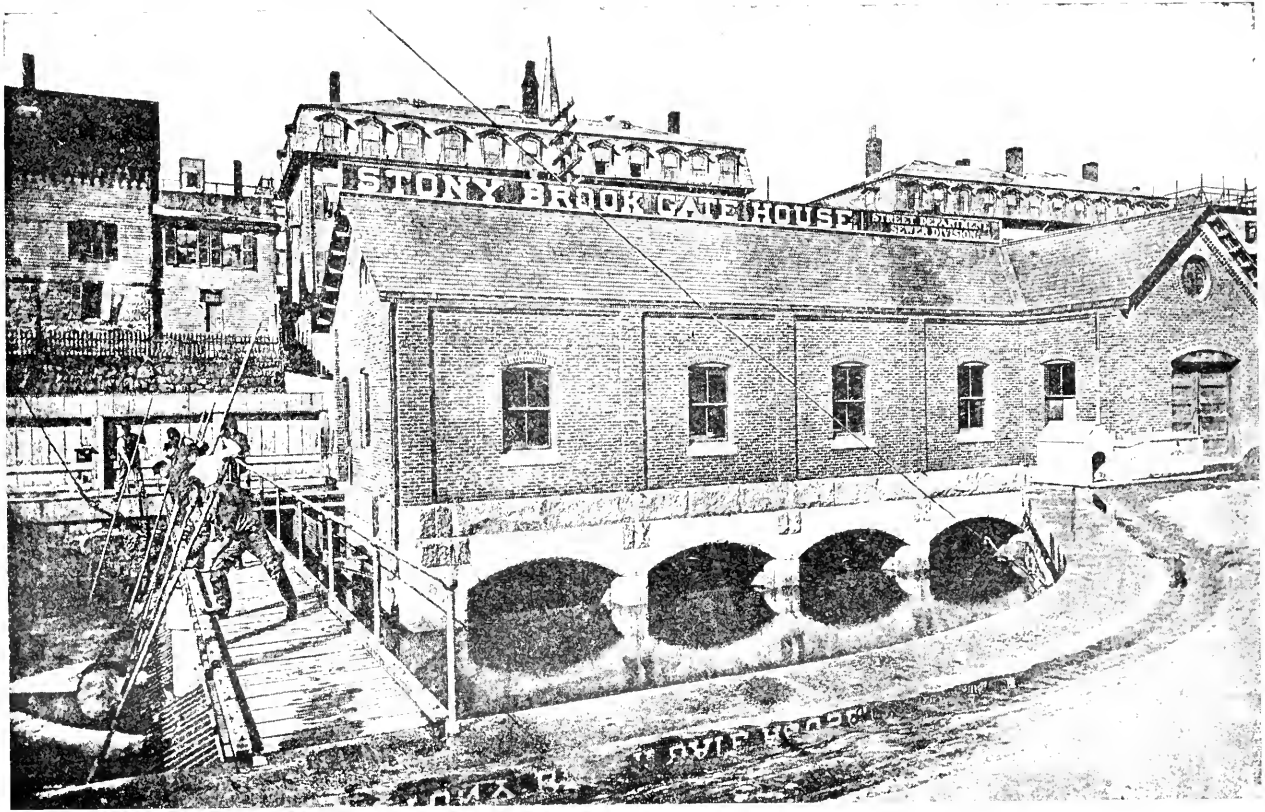


STONY BROOK GATE HOUSE CLEARING SCREENS DURING A FLOOD.

FOUNDATION OF GATE HOUSE SHOWING OPENINGS INTO THE NEW CHANNEL.

charge; an engineering force was appointed, and plans and specifications for the work were at once prepared; and in October, 1887, work was started on the first section from Pynchon street across the Boston and Providence Railroad tracks to Tremont street. The following is a description of the work in detail:

The work of the improvement begins at a point on the brook just back of and above the car stables at the Tremont street crossing of the Boston & Providence R. R. At this point the old channel of the brook is enlarged to a width of 60 feet, for the purpose of constructing a settling basin in which the sand and gravel washed down by the water of the brook may settle. A low dam, 18 inches high and 60 feet long, is built across the settling basin at its lower end, to retain the sand and gravel. The settling basin is divided longitudinally by a wall, which will admit of one side of the basin being cleaned out while the other is in use.

The cross dam at the lower end of the basin is surmounted by a heavy sloping iron screen, which will prevent the passage downward of logs or large cakes of ice. A small foot-bridge is built just over the screen, on which men may stand in time of flood, and keep the screen free from obstructions. Immediately back of the dam and screen is the inlet chamber. This chamber is 40 feet long and 17 feet wide, and extends to the depth of 12 feet below the channel of the old brook. There are five openings into the inlet chamber, through which the water can be admitted in time of storm. These openings are each 10 feet long, and are raised above the level of the old brook channel, so that the ordinary flow of the brook cannot enter the chamber, but will continue in the old course. The openings into the inlet chamber are provided with stop planks, so that the amount of water which is to enter the chamber can be regulated. A dam just below the inlet chamber will admit of all water being shut off from the old channel and passed into the chamber, should it ever be advisable to do so.

Section One.

At the lower end of the inlet chamber the conduit proper commences. This conduit is a brick and stone structure of horseshoe form, with interior dimensions of 17 feet in width by 15½ feet in height. The conduit crosses the railroad track of the Boston & Providecne railroad on a sharp reversed curve, and then runs parallel to the railroad track until Tremont street is reached. The excavation in this section is largely in ledge, and on account of the difficulties and dangers incident to the prosecution of the work under and alongside of the railroad, it was undertaken by the city instead of being let by contract. The railroad track was supported over the open conduit trench by means of heavy iron girders, 3 feet deep and 36 feet long, placed at

right angles to the conduit trench. These girders were eight in number, and supported the heavy 14×16-inch timbers which carry the railroad tracks. The difficulty of the coustruction of Section 1 was increased by the high retaining wall surmounted with tenement houses, which runs parallel with the railroad track, and so close to it that there was barely room for the excavation of the trench. In some cases the raiload had to be undermined to allow of the construction of the masonry.

Section Two.

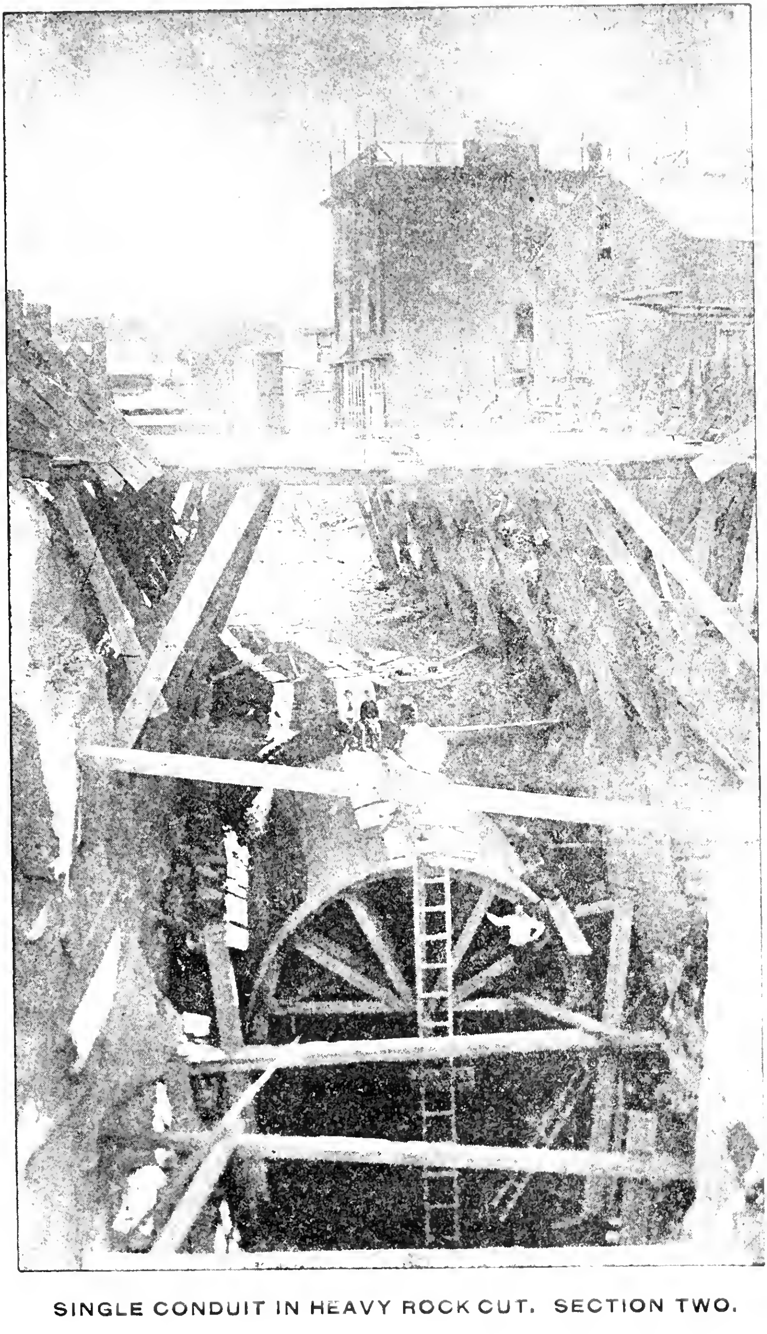
This section of the conduit begins at Tremont street, close to the Roxbury crossing, extends through private land and Gurney street to Parker street. The original location recommended by the Stony Brook Commission has been changed at this point, as further study and estimates showed that a more economical location could be obtained. The conduit is built entirely through ledge in this section, the depth of cut varying from 23 to 35 feet. The ledge was excavated by contract, and the work presented no very great dfficulty. It is remarkable, however, for the large amount of work done in a short space of time, 9,300 cubic yards of rock having been excavated in 18 weeks. The brick masonry of this section was put in by the city.

Section Three.

This Section begins at the junction of Gurney and Parker streets, and extends down Parker street a distance of 600 feet. Rock is encountered for a distance of about 150 feet, after which the excavation is in clay, sand and gravel. The depth of the conduit on Gurney street is 35 feet, and at the end of the contract it is 24 feet below the surface of the street. The dimensions of the conduit on this section are 17 by 15½ feet, the form being of horseshoe shape; the structure is built on a concrete bottom, with heavy rubble stone side walls and brick arch. The concrete bottom and stone side walls are lined with eight inches of brick work, and the brick arch which covers the conduit is twenty inches thick. The inside of the conduit presents a smooth brick surface. This section of the conduit presented great difficulties in construction. The easterly side of Parker street is lined with six-story brick and stone breweries, which tower upward to a great height. The excavation of a trench 35 feet deep and 28 feet wide in sand and gravel alongside such huge structures required the greatest care and precaution, as any movement of the soil would cause the settlement and cracking of the walls of the buildings.

Section Four.

This section starts at the end of Section 3, and extends along Parker street a distance of 600 feet. Owing to the elevation of Parker street, it was found impossible to build the conduit as a single channel, as its top would project above the elevation of the street. It was conse-



SINGLE CONDUIT IN HEAVY ROCK CUT. SECTION TWO.

VIEW AT "BELL MOUTH" SHOWING END OF SINGLE CONDUIT AND BEGINNING OF DOUBLE CONDUIT.

quently built as a double conduit. Each of the twin conduits is 12 feet high and 12.5 feet wide. These conduits are separated by a brick wall 16 inches thick, and are covered by brick arches 16 inches in thickness. The same general plan of construction is adopted as in the large single channel: that is, a concrete bottom, with stone side walls, lined with brick and then covered with brick arches. The material in which this conduit is built is sand and clay for 250 feet, after which mud is encountered. Where the mud occurs the conduit is founded on piles. Bents of 13 piles, spaced 3 feet apart are driven through the mud into a solid bearing in the underlying clay. The bents are then capped with long spruce timbers 10 inches square. On these timbers 4-inch spruce planking is fastened, and the masonry built on the plank foundation. The double conduit requires a very wide trench (37 feet) and occupies the whole street. The work was done by contract.

Section Five.

This section is a continuation of Section 4, and extends down Parker street 600 feet. The conduit consists of double channel similar to that of Section 4. The first 200 feet of the conduit are built on a pile foundation, after which the mud is passed, and the conduit for the balance of the section is founded directly on the clay. The feeding canal of the Sewell & Day cordage works runs close to the side of the trench in this section, and care had to be exercised in the bracing of the trench. The section was built by contract.

Section Six.

This section extends along Parker street to the junction of Huntington avenue. The material excavated from the trench consisted of clay, sand and gravel. The conduit is of the same size and shape as on sections 4 and 5. Considerable water was met with on this section, as the material passed through was porous and admitted the water from the neighboring canal. Steam pumps, working day and night, were required to keep the trench dry. The work was done by contract. At the lower end of this section a large amount of work was necessitated by the construction of the conduit. The top of the conduit extends from 3 feet below the surface of the street to a depth of 17 feet. It thus makes a dam across Huntington avenue at this point, and necessitated the construction of an expensive siphon to conduct the sewage in the Huntington avenue sewer under the conduit. At this point the conduit is founded on quicksand, and as it would be impossible in the future to build a sewer under the conduit without great risk of undermining it, the intercepting sewer which was to be built by the Sewer Department to drain Brighton and the Charles River valley was constructed at this point simultaneously with the conduit. Overflows and gates connecting the conduit and sewers are constructed at this

point in order that the conduit may be emptied of water whenever it is necessary.

Section Seven.

This section extends from Huntington avenue through the Back Bay Park to the outlet, a distance of about 650 feet. The double conduit ends at Huntington avenue, and from this point through the Park the channel is open, and presents the appearance of an open canal, 42 feet wide and 600 feet long. The banks of this canal slope up and reach a width of 92 feet at the top. The floor of the canal is made of concrete and the banks up to the water line are paved with stone to preserve them. From the water line to the top of the bank the slope will be sown with grass seed and shrubbery planted, thus giving to the waterway an ornamental appearance. At a distance of about 500 feet from Huntington avenue the canal will be crossed by a stone arch bridge of a construction that will be in harmony with the general landscape features of the Park. The work of this section was done by the city.

The cost of the whole conduit, is $650,000. The work was completed practically in one working season, and it is doubtful if there are many cases in this country of a work of such magnitude being completed in such a short time.

Incidental to the construction of the conduit, the main outlet sewer for the drainage area in the vicinity of Parker Hill, comprising 130 acres, was reconstructed. The sewer was moved from Parker street (its former location), and reconstructed in Phillips, Ward and Vancouver streets and Huntington avenue. This outlet sewer, with the necessary changes in branch sewers, involved the expenditure of $60, 000, and was not contemplated in the original estimate.

The entire work, both City and Contract, was done under competent inspection, and the character of the masonry is first-class in every particular. Diagrams and measurements taken in the conduit after completion, show that the masonry has held its shape and that the settlement of the crown of the arch was inconsiderable. As far as I am informed, the conduit is only surpassed in size in this country by the Washington sewer and the Mill Creek sewer in St. Louis. I have been unable to find that any sewer in London or Paris equals this conduit in size.

Work was commenced on the conduit in October, 1887, and in December, 1888, water was sent through the new channel.

Of the $650,000 expended, about $200,000 was paid for labor employed by the City, the balance being expended on contracts and materials.

The completion of this conduit does away with all danger of flood-

ing on Stony Brook below the Roxbury crossing, as all the water can be turned down the new channel at a moment's notice.

The flooding of cellars and meadows will still continue in Jamaica Plain and West Roxbury until such time as it is deemed advisable to extend the conduit. The practical workings of the Inlet Chamber and conduit leave nothing to be desired; and it is well worth a visit to the Inlet Chamber during an extraordinary storm in the winter, to see the water pour into the new conduit from the openings in the Inlet Chamber.

STRAINS IN PORTAL OF THROUGH BRIDGES.

By Albert H. Howland, Member Boston Society of Civil Engineers.

[Read April 20, 1892.]

The importance of providing adequately for the strains resulting from wind pressure upon bridges and similar structures was brought forcibly to the attention of engineers by the failure of the Tay Bridge.*

The amount of that pressure having been assumed, the resulting strains are very readily determined for the horizontal bracing between the chords: but for the *portal of through bridges* the calculation is more complicated. The generally accepted method of calculating these strains is very plausible, but it gives results that are only about *one-half or one-third as great as they should be.*

Most of the various forms of portal bracing in common use may be classified as follows:

1st. Those consisting of an upper and lower horizontal strut with diagonals between: and

2nd. Those consisting of one strut with corner brackets.

In the following I give methods of calculating the strains in these cases under two assumptions as follows:

---

*This paper was written in Jan. 1881, and at that time the failure of the Tay Bridge was a recent event. The disaster at Moenchenstein in Switzerland last summer has been attributed to the lack of portal bracing, and it seems to me altogether probable that that was a contributing cause if not the chief one. The importance of portal bracing is a matter that I brought to the attention of the society early in 1881, (proceedings, page 138) which is the first time, so far as I know, that the magnitude of these strains has been pointed out. Similar conditions are liable to occur in the case of towers for trestles or other purposes, and of high buildings exposed to wind. A. H. H.

(*a*), end posts free to bend laterally at base: and

(*b*), end posts fixed at base.

The letters, *A*, *B*, and *C*, which designate points on the figures, are also used to represent the forces or components acting at those points, a subscript *h* or *v* showing whether the component is horizontal or vertical. Let H = lateral force acting at top corner of windward truss. Assume that the horizontal re-action at foot of each end post is $\frac{1}{2}$ H.

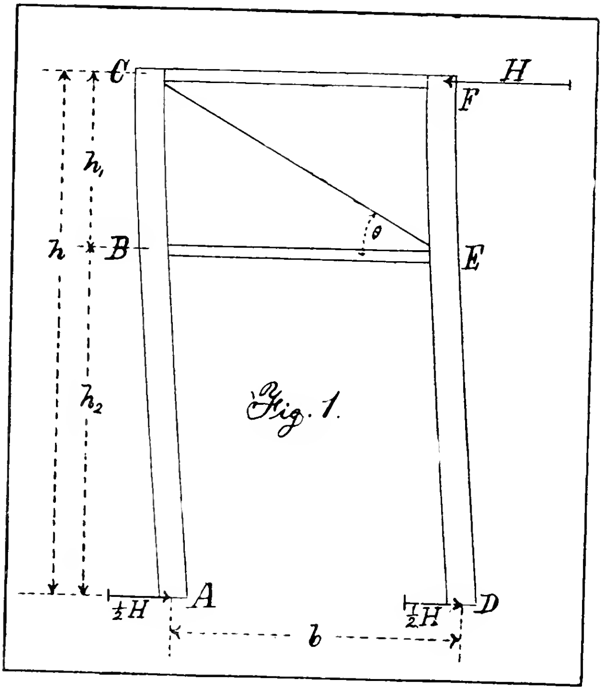


Fig. 1.

(This assumption would not be exactly realized in practice, but the error involved is immaterial.)

Case 1 (*a*). The strain produced on B E (fig 1.) by A C acting as a lever is $\frac{1}{2}$ $H \dfrac{h}{h_1}$: the strain on C F by lever D F is $\frac{1}{2}$ $H \dfrac{h_2}{h_1}$, to which is to be added H which acts on C F directly, making a total of

$$H\left(\frac{1}{2}\,\frac{h_2}{h_1} + 1\right)$$

for C F.

Strain on C E = total of horizontal forces acting at C × sec. θ

$$= \left(\tfrac{1}{2}\, H \frac{h_2}{h_1} \text{ by lever } A\ C \text{ and } H \left(\tfrac{1}{2} \frac{h_2}{h_1} + 1 \right) \text{ by strut } C\ F \right) \times \text{sec. } \theta$$

$$= H \frac{h}{h_1} \text{ sec. } \theta.$$

Strain on end post $A\ C$ = strain as member of truss + vertical component of strain on $C\ E \left(\text{viz: } H \frac{h}{b} \right)$ + transverse strain which is maximum at B.

Case 1 (b). Let fig. 2 represent an end post under action of the

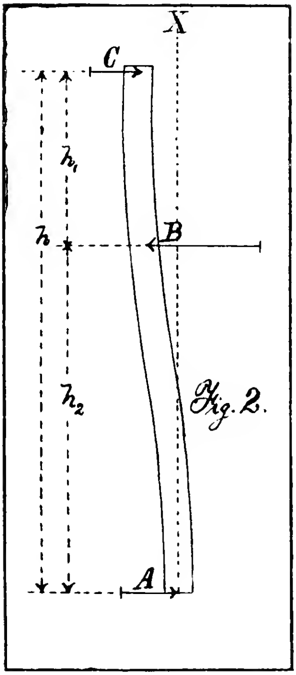


Fig. 2.

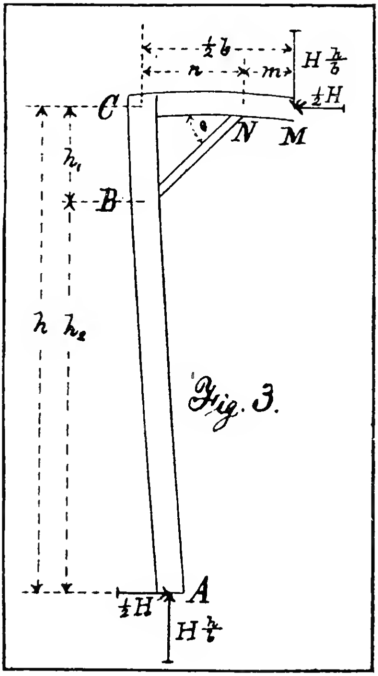


Fig. 3.

lateral forces, viz: A (which is $\tfrac{1}{2}\ H$), and B and C which are as yet undetermined. Let d_C and d_B be the lateral deflections from $A\ X$, the original direction of the post. Then according to the elastic relations

$$d_C - d_B = \frac{1}{E\ I} \left(C \left(\frac{h_1^3}{3} + h_1^2\, h_2 \right) - \frac{H\ h_1\ h_2^2}{4} \right).$$

Now the lateral forces distort the original rectangle $B\ C\ F\ E$; let δ = the angular distortion and put $\Delta = h_1$ tan. δ: I estimate

this to be $\Delta = .0004\ b\ (\sec.^2 \Theta + 0.4)$ approximately. Equating this to the value of $d_c - d_B$ given above, and reducing, we have

$$C = \frac{\frac{1}{4} H h_2^2 + E I \tan. \delta}{\frac{1}{3} h_1^2 + h_1 h_2}.$$

Then strain on $B E = C + A = C + \frac{1}{2} H$; strain on $C F = C + H$; and strain on $C E = (2 C + H) \sec. \Theta$; moment on post at $B = C h_1$.

Case 2 (*a*). $A B C$ (fig 3) as a lever is acted upon by three horizontal forces: one of these $C_h = \frac{1}{2} H \frac{h_2}{h_1}$, which = tension on $C N$; compression on $C N$ upon reversal of strains would be

$$C_h + H = H \left(1 + \frac{1}{2} \frac{h^2}{h_1}\right);$$

compression on $N M = \frac{1}{2} H$: tension or compression on $A B = H \frac{h}{b}$, on $B C = H \frac{h}{b} \times \frac{m}{n}$, on $B N = \frac{1}{2} H \frac{h}{h_1} \sec. \Theta$; bending moment at $N = H \frac{h}{b} \times m$, at $B = \frac{1}{2} H h_2$.

Case 2 (*b*). My solution of this case involves processes more tedious than those already given, so I omit it, giving however a few results below.

EXAMPLES.

Case 1. Let H = 10,000 lbs.; $h_1 = 9'$; $H_2 = 18'$; $h = 27'$; $b = 15'$; $I = 800$. Then, according as assumption (*a*) or (*b*) applies, the strain on $C E$ will be 35,000 lbs. or 24,000 lbs., results that are *two or three times as great as the usual method of calculation gives.*

Case 2, Let H = 10,000 lbs.; $h_1 = 5'$; $h_2 = 20'$: $h = 25'$; $b = 15'$; $m = 2'\ 6''$: $n = 5'$: $I = 1,000$. Then, according to which of the two assumptions applies, the strain on $B N$ will be 35,000 lbs. or 22,000 lbs., and that on $C N$ will be 30,000 lbs. or 21,000 lbs. These strains are two or three times as great as the lateral force that causes them.

Methods somewhat similar to those given above are applicable to other forms of portals, and to roofs supported on columns.

AN ENGINEERING ITEM.

By F. E. Sickels, Member Engineers' Club of Kansas City.

[Read October 10, 1892.]

In looking back over the progress of improvements in transportation of passengers and freight we may notice the short cast iron rail laid on stone blocks of the last century, and the strap rail of the early part of this century, laid on continuous stone or wood sleepers, and then the T-rail laid on cross ties of the present day. The locomotive first exhibited in London as a toy in the beginning of this century next created a violent opposition by running over a road through fields in which cattle were grazing (1812), this provoking the owners to appeal to the courts praying that their cattle may be permitted to enjoy their food without being annoyed by the noise, smoke, etc., of such a traveling monster. Next the passenger locomotive was advertised to start "weather permitting" and now we have locomotives weighing over sixty tons hauling trains at the rate of sixty miles per hour.

The steamer of the last century is found in the beginning of this to have become a commercial success. The steamship of 1819 made one trip to Europe and on her return was sold, the machinery for old iron and the steam cylinder to be used as a blowing cylinder to a foundry furnace, doing service for thirty years. The next steamship to cross the Atlantic only made one voyage. The third attempt was made by a steamship which returned to England and did not again try to cross the ocean. The fourth attempt (the Great Western) was a commercial success and we now have steamships nearly 600 feet long, two in course of construction 643 feet long, and one recently commenced 700 feet in length.

While the progress here indicated has been recently made, it is true that the knowledge of the thoughtful engineer of the present day is in advance of his practice. The tendency of capital, as a general rule, is to embark in enterprises only after their money earning capacity has been established. Projectors of new designs must be able to show that money can be made by following their plans before they can hope, in most cases, to succeed in obtaining the necessary funds to insure success. Any wide departure from the plans now in use invites criticism from the prudent men of money, hence the conservative engineer must propose only such plans as involve the use of what has been previously tried and found profitable. An engineer who strikes out boldly with new plans, however good they may be, will thereby lose the confidence of a large majority of investors and come to be regarded as unreliable. If possible, in proposing a new design,

engineers should show that all parts have been well tried separately and that the combination suggested does not involve an experiment. Much of this timidity of capital has been fostered by the failure of schemes inaugurated without due consideration by incompetent or speculative engineers who had the ability to impress capitalists with a belief in the soundness of their judgment, while their only real intellectual gifts consisted in an intuitive knowledge of human nature.

Notwithstanding all these drawbacks, however, the rapid strides in engineering during the present century are calculated to encourage the hope that the next century will not close until the earth has on its surface many gigantic exhibitions of human skill. The tendency to construct engineering works of great magnitude has already pushed engineering practice much in advance of what it was even twenty years ago. The consolidation of routes under one management has progressed until traffic arrangements are in effect over the civilized world. The outlook for the future as indicated by the experience of the past is that an international passenger and freight line around the world will be established, over which local interest will have no control. Ships of 1,000 feet in length and 100 feet beam will be built, and these will not come into harbors, but will find their berths in ferry slips built out from the shores of the ocean. These ships will be loaded and unloaded within forty-eight hours of twenty thousand tons of freight which will be received on tracks on each side of the ferry slip, thus saving one-third to one-half the time now required. They will run in and out of these slips in storms and foggy weather, and all the anxiety of coming into port will be avoided. No special pilots will be required to assist in navigating them as they can run at full speed onto soundings, and their whistles will be answered so that they may know exactly where they are in the thickest fogs. If off their course, their captains will make the corrections and keep on under full headway until arrival in the slip. Collisions with passing vessels will be avoided, as coasting crafts will naturally give these ferry slips a wide berth, and when they hear the whistles of the big ships in heavy fogs will keep out of the way as they will have the wide ocean to steer to. These large steamships will pay, as they can afford to do the business for at least one-third of the present cost, six days on the Atlantic and two in port, using three-fourths of the time for transportation. Passengers on these ships can remain on deck in all kinds of weather without experiencing sea-sickness, as the rolling and pitching motion of such large vessels is too slow to produce nausea. With a draft of thirty-five feet and a promenade deck of twenty-five feet above the water, the waves even in the heaviest weather would not come on board to any great extent.

The proprietors of the present trans-Atlantic lines destroy the val-

ne of their property in old steam vessels as fast as they build larger passenger ships, as the smaller ones then become of little value. and it is reasonable to infer that a line of ships as here indicated would control the great bulk of travel, especially when connecting with a through railway route across the continent, with corresponding ships on the Pacific, making a schedule time of twenty days from Europe to China across America, and half this time by through rail across Asia. The cost of through railroads to connect with these steamship lines will necessarily be excessive, as locomotives weighing 100 tons will be necessary, if they remain in use, to insure hauling the trains with all passenger requirements and conveniences in all kinds of weather and on schedule time. The route will be selected without regard to present local requirements, so as to build the best through line without grade crossings as far as possible, and it will therefore not pass through many of the present large cities.

New cities will spring up along this international route, and these will be different from the present ones in that they will be a collection of conveniences without nuisances, whereas the present cities are a mixture of conveniences and nuisances. For sanitary reasons animals will not be permitted in these cities, in civilized countries. Local traffic now requiring horses will be accomplished by means of storage batteries, compressed air or steam. The sewerage, drainage, the supply of heat and cold, water and light, etc., will be arranged to protect the citizens from any of the inconveniences which now accompany their use in the present cities. These new cities will come into competition with the old, with the advantages in favor of the new.

It may be urged that cities near these ocean ferry slips will be liable to attack from hostile fleets in time of war. It is true that fleets have one feature that gives them great power in some cases, that is, their ability to act together to produce an enormous concentration of fire. But they can be readily repulsed by torpedoes in various forms, such as fixed, moving, floating, double and concealed moving torpedoes. Machine or rapid firing guns are relied upon to act against these torpedoes, but such reliance is misplaced as against the most formidable torpedoes such as the invisible fixed and moving. As long as batteries afloat are relied upon to attack shore cities their efficacy is extremely limited by reason of the ease with which their floating power may be destroyed by the torpedoes of recent design.

It may be expected that this through line around the world will have a depressing effect upon some interests and will meet with much opposition, but the younger engineers of the present day can look forward with hope to see the project here outlined accomplished together with many other engineering works which will tax their best energies.

As many subjects have been already proposed for discussion by the gathering of different nationalities at Chicago, perhaps it may not be out of place to propose that the subject of an international railway and steamship line be offered for consideration. The practical bearing of such a proposition consists mainly in the fact that all great changes require long previous discussion to the end that the public may to some extent be prepared for them when they occur.

WATER PIPE AND PRESSURES IN CITIES AND TOWNS.

By W. F. Goodhue, Member, Wisconsin Polytechnic Society.

[Read January 11, 1892.]

In this paper when commenting upon the general efficiency of a water-works system as planned and built nowadays, reference is made at the commencement to the water system of Chicago; not however with a view to awaken a critical discussion of that subject, nor to comment derogatory to its numerous projectors, but to show in what manner the water system of Chicago compares in its inception and growth with those of smaller cities in the west: how the Chicago system has grown to its present magnitude to conform to urgent needs, occasioned by the remarkably rapid growth of that city: also show something of the difficulties encountered in enlarging a system that was too contracted at its inception. The history of the Chicago system has, in this respect, been paralleled by other cities in the north-west.

Sometime last summer a prominent official of the Chicago Fire Department visited Milwaukee, and while here was interviewed by a newspaper reporter concerning "Fire and Water," as these subjects are tersely expressed in municipal parlance. If this officer was correctly quoted he said, substantially: "That the Chicago Fire Department had concluded that Chicago and all other large cities should have a system of high pressure water-works, independent of the system supplying consumers;" which means, allowing me a free interpretation of that officers' idea: that there should be in all large cities two separate systems of water-works: one of great pipe capacity and high pump pressure for the extinguishment of fires and a secondary system of lesser pipe capacity and pump pressure for supplying consumers. How recently the Chicago Fire Department officials have come to such a conclusion I do not know, but a similar opinion has long been entertained by the earlier engineers of the Board of Public Works of that city. In 1876, Mr. E. S. Chesbrough, then City Engineer of Chicago, laid about eight miles of twenty-four and thirty-six inch pipe in that city to meet

a much needed requirement of large pipe capacity, and a large pumping plant was erected at the same time to furnish higher water pressures throughout the city.

Concerning the Chicago water system at that period, Mr. Chesbrough said: "The system as it now exists is not the result or carrying out of any definite plan formed in the beginning, for no one then knew how rapidly the city would grow, in what direction the greatest increase would take place, nor what would be the demand for water in proportion to the population; all these conditions greatly exceeded the views of the first projectors of the works."

Mr. Chesbrough, I may add, died some years ago and the population since his death has nearly doubled; the system he enlarged and rebuilt to meet the requirements of his day, is now being again enlarged to meet a much greater demand for water than he had to face twenty years ago. In 1868, Mr. Chesbrough completed the first lake tunnel for the city's water supply, and this tunnel when completed was held to be adequate for some years to come. In 1875, he completed the second tunnel, and the combined supply of the two were then held to be adequate for some years to come. Now the city is building a third tunnel, larger than the two already built, and time will tell if the three combined will furnish an adequate supply of water for some years to come.

The pipe capacity of Chicago's system at the time of the great fire in 1871, is worthy of more than a passing notice; undoubtedly it lacked in capacity when that great calamity fell upon the City. After the great fire of 1871, and the smaller yet disastrous fire of 1874, the Citizen Association of Chicago was organized and this body investigated quite thoroughly the water system of the city, and the result of this investigation was an urgent demand for larger water mains. At this time the largest main in the city was but 16 inches in diameter, and a large proportion of the street supply pipe was 3 and 4 inches in diameter. Had the system contained the large 24 and 36 inch mains in 1871, that were afterward laid by Mr. Chesbrough in 1876, it is extremely doubtful if those two great fires would have made the disastrous headway they did, or would have become the famous events of that great city.

If memory serves me correctly regarding statistics of Chicago some twenty years ago, there were in that city about 52,000 buildings in 1871; of this number about 4,000 were masonry s ructures, the remainder were wood structures and were so sandwiched together that one served as kindling wood for the other. I well remember that after both of the fires had occurred there were complaints made of an insufficiency of water, how well grounded these complaints were I cannot now say, but the alleged insufficiency of water might have been an in-

sufficiency of pressure, due to the excessive use of water at those particular times, also to the great mileage of small pipe the water system of Chicago had at that period. In 1871, the total mileage of pipe was about 380 miles; of this amount 293 miles consisted of 3, 4, 6 and 8 inch pipe; the remaining 81 miles were 10, 12 and 16 inch pipe; a majority of the hydrants were single nozzled. The area of the City was then about 30 square miles; its population about 250,000. This contracted pipe system, together with the preponderance of wood structures were disadvantages which told heavily against the efforts of the fire department in the great conflagration. In 1876, Mr. Chesbrough said in his annual report: The increase of population and consequent growth of the city and the greatly increased height and value of buildings in its business portions, have demanded a greatly increased capacity for furnishing water,—and to meet this requirement he tells what he has done: "a grand circuit, four miles north to south, and two miles from east to west, of 24 and 36 inch pipe has been laid, while the laying of 4 inch pipe has been discontinued." He further says: "the city as a whole and especially its most valuable portions are much better protected against fire than ever before." The average daily consumption of water in 1877 was 42,000,000 gallons.

Summarizing briefly, the water system of Chicago has been from its inception a forced growth, and from its many enlargements is to-day a somewhat involved and intricate system; it was never a broadly conceived plan, commensurate with the city's commercial importance, nor its manifest destiny. Of course it cannot be expected that in 1850, the then city authorities would lay a 36 inch water main, but in 1870, with a population of over 200,000, it took a tremendous risk by attempting to afford fire protection to a city of that size, with the same main pipe capacity originally designed for a city having only one-fifth the population and one-third less area. In 1865 the water supply was located on the lake shore and the water furnished the city then was a villainous compound of dead fish, sediment and shore washings. It was the bad condition of the water supply, more than any desire to afford better fire protection, that induced the city to build the first lake tunnel. In 1868, when this first lake tunnel was completed was the time to increase the pipe and pump capacity of the city system, and thus possibly have prevented the great conflagration three years later. But the projectors of Chicago's water supply in the different periods of enlargement labored under the same disadvantages that are common to the municipal engineer everywhere. That narrow minded conservative element which exists in all cities would never allow the execution of work from plans for a water system, based upon broad lines of utility, efficiency and considerations of future growth and development; the average conservative citizen is never impressed with fu-

ture needs when considering present improvements; but the conservatism of corporate authority must be recognized and is recognised by the engineer because it controls the finances of the corporation, yet there are many known instances where this conservatism has entailed a heavier additional expense upon a city, than would otherwise have occurred had it existed with less strength of purpose at the beginning of the outlay.

In some towns where I have been engaged on work, this element has wanted sewers built abnormally large (an extravagant incongruity by the way) and then wanted water pipe extremely small. It wants small pumps, regardless of the required pump duty, because they are cheaper than the large pumps; they want light iron bridges because they are cheaper than heavier ones, and at times it is extremely difficult to convince these so-called conservatives, that the same efficient pressure cannot be obtained from 500 feet of 4 inch pipe, that can be had from 500 feet of 6 inch pipe; this must appear to be a superfluous statement of fact, but the engineer must firmly and convincingly stand by his plans if he would preserve their practicability, otherwise the efficiency of the plant he is building will be seriously curtailed and in many instances where he does stand by his plans he is accused of captiousness and having "a desire to run things his own way," implying that his motives are purely personal and not pro bono publico. Unfortunately, the engineer is a man who gets his living by spending individual or public moneys and he must spend the money intrusted to him in a manner that is satisfactory to those who furnish it, if he does not do so he loses the opportunity to earn a livelihood. Engineers are sometimes charged with making errors of judgment when prosecuting their work, which upon investigation prove to be, not errors of judgment but a judgment restricted to conform to the funds provided for the work in hand, which are also restricted.

The chief of the Milwaukee Fire Department comments upon the remarks made by the Chicago Fire Marshal, as follows:

He said: "The high pressure service is used in a great many towns and small cities, and as a rule gives satisfaction. For fire protection in the suburbs it would doubtless prove all right, and it was this, I think, that the Chicago Fire Marshal contemplated. But for use down town among the five or six-story buildings I think the system would prove a failure. At a big fire our engines have to carry a pressure of from 200 to 300 pounds. This is done on a short 'lead' of hose. But when you come to put this pressure in a long 'lead' of iron pipe I am afraid the scheme would be impracticable. While high pressure service is all right for small cities, and perhaps for suburbs of large cities, it will have to be greatly perfected to make it available for general use. Milwaukee will continue to use fire engines, and I think neither

the Chicago Fire Marshal nor myself will live to see them discarded."

The real obstacle to the use of a high pressure service in Milwaukee, as well as in all our larger cities, is the high buildings erected nowadays, "sky scrapers" as they are called, and because of these extremely tall buildings fire engines cannot be abolished in our large cities: they are essential at the burning of tall buildings inasmuch as they serve to reenforce the pressure as the water passes through them from the hydrant.

The building in which we are now assembled is 130 feet high, an effective fire stream that will play upon this roof, the engine being located at the nearest hydrant, would be substantially; 100 feet of hose, a 1¼ inch smooth nozzle, and would require the following stated pressures: 125 pounds pressure at the engine, which would be 90 pounds at the nozzle, throwing a stream 148 feet high, or 18 feet higher than the building; the discharge would be 294 gallons of water per minute. Such a pressure is an extreme one and would undoubtedly be considered as beyond the safe working limits of any system of water works. Yet the water system of all cities should be of sufficient power and capacity to afford such pressures, for reasons which I will state further on.

Cities of the second and third class contracting for a water system either by franchise, or for its own construction, should insist upon certain conditions:

First. The water pipe should be of sufficient diameter and the pumps of sufficient power to give adequate hydrant pressure for the extinguishment of fires, without the aid of steam fire engines.

Second. The maximum hydrant pressure to which the city shall be entitled and for which it may call for at all times should be stated in the contract.

Third. The maximum daily pressure to which the city is entitled should be stated in the contract as well as the minimum daily pressure.

I am aware that some franchise companies hold these conditions to be extreme and say that they cannot be complied with, and I have been roundly rated for incorporating such conditions in city franchises, but I answer that they can be complied with, that they are not impracticable and further more they are fully complied with in a very satisfactory manner in four cities in Wisconsin. I am also aware that such conditions cannot be complied with in a majority of the cities of this State, having water systems, indeed there are very few cities in the whole West that can and the reason therefor is obvious.

As an instance of efficient pressure under these conditions in a small town, I will cite the village of Burlington, Wisconsin, a place having

a population of 1,800; the water system of Burlington was built in 1890 and is owned by the village.

The static pressure from the stand pipe in the business part of the village is 80 pounds, and when the works were tested for acceptance there was not a hydrant gauged that registered less than 70 pounds, available pressure. The contract for the pipe laying required a test of 100 pounds pressure (direct from the pump) at any hydrant in the system, to be maintained as long as desired by the authorities of the village. At a hydrant located about 3,700 feet distant from the pump house this pressure was successfully maintained for over an hour, which was as long as was desired. The main pipe of the system is 8 inches in diameter and is about our thousand feet long, the pipes branching from it are 6 inches in diameter. The village does not own a steam fire engine and there is no intention to purchase one. Near this village of Burlington is a city having about four times its population, with a water works plant built by a franchise company, that cannot maintain a pressure of 50 pounds at the hydrant without injury to the plant, nor can it do so in any event if one or more hydrants are open.

Considering pipe pressures in a larger place I will cite Manitowoc, Wisconsin, a city with a population of about 8,000. It has 15 miles of pipe and 150 hydrants; its largest main is 16 inches diameter and about 4,000 feet long, a main that is of the same diameter of the largest main in Chicago at the time of the great fire in 1871. Manitowoc granted a franchise to a company that built the works. There is no pipe in the system less that 6 inches diameter, excepting hydrant connections which are 4 inches diameter.

It is one of the conditions of the franchise as granted, that the works when built should be subjected to a test of 120 pounds (direct pump pressure) at any hydrant in the system, the hydrant to be chosen by the city council, and such pressure should be maintained as long as desired—furthermore the works were to be subjected to this test, annually, during the existence of the franchise. This last mentioned condition is unnecessary and conveys no advantage to the city nor is it beneficial to the pipe system. After the franchise was awarded I returned home on the same train with the half dozen or more bidders who had been to Manitowoc to secure this franchise. Even now my ears tingle when I think of the roasting those gentlemen gave me that day on the train, because of that unheard of, and very excessive pressure of 120 pounds at the hydrant. I did not think the pressure then required, unreasonably excessive, nor do I think so now. A newly laid pipe system should always be tested, before acceptance, with pressures somewhat greater than any future exigencies may require; it is a test of the strength of the pipe laid and of the excellence of the calking.

The pipe is supposed to be tested to a hydrostatic pressure of 300 pounds per square inch at the foundry, if so the same pipe should be able to withstand a pressure that is less than one-half of this number of pounds, after it is laid in the trench, ready for the use for which it was made. If there are cracked or weak pipe, or imperfect joints in a pipe system it is far better to blow them out under heavy pressure before the work is accepted, than to see them blown out, after acceptance, when a conflagration is raging: furthermore when the contractor who is laying the pipe knows that his work when done will be subjected to a heavy pressure, and if breakages occur that are caused by imperfect work, which he must repair at his own expense, he is careful to do good work. I find that a clause of this kind, included in a contract for pipe laying, saves the expense of a pipe laying inspector. The recollection of the roasting received on the train has not cured me of stipulating high pressures in water works franchises, for I have since repeated the offence several times for the other cities. The principal reason why water companies object to such pressures, is: that to maintain them they must use larger pipe than they otherwise would, requiring a heavier investment than they wish to make. A majority of the pipe laid in Wisconsin cities, by franchise companies, is 4 inches in diameter and seldom exceeds 20 pounds weight per lineal foot, with weight of bell and spigot included, and as a rule are very inferior pipe.

When the water system of Manitowoc was completed, came the day when the tests were to be made. The water company's superintendent, voluntarily run the pressure up to 145 pounds at a hydrant located nearly one mile from the pump house and he held this pressure for some time to the entire satisfaction of the city council who were present. The franchise requires the daily maximum pressure to be 55 pounds and greater when called for by the fire department. Its maximum pressure, or its equivalent is: to furnish eight streams, each with 300 feet of hose and 1⅛ inch nozzle, the eight streams to be taken from any eight hydrants in the system. These streams require a hydrant pressure of 66 pounds; throwing a vertical jet 80 feet high, discharging 155 gallons per stream, per minute, which amounts to 1,250 gallons per minute in the aggregate. The city has sold one fire engine and has another for sale; these engines have not been taken to a fire since the works were built, some three years ago.

The usual and customary franchise adopted by a large majority of the cities in the west, contain stipulations for certain tests of the system before acceptance. That is: the works must successfully withstand certain tests before the period of hydrant rental shall begin. A majority of the tests required are so puerile and in-efficient that they should not be dignified with the name.

In noting from a franchise ordinance granted by a city located

within fifty miles of Milwaukee, the tests stipulated therein are as follows: "The cast iron pipe laid shall be of ample size to carry out the provisions of this contract and afford the city, *where laid*, first class fire protection.

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Upon the completion of said works they shall be tested as to their power and capacity; when said works shall throw water with the aid of its pumps, from any six hydrants, located in the business or manufacturing part of said city, at one and at the same time—one stream from each hydrant, through 100 feet of 2½ inch hose and one inch ring nozzle, to a height of 100 feet and 132 feet horizontally, in still air for two consecutive hours: or, two streams from any two hydrants selected by the city council, through 800 feet of hose and one inch nozzle, above the height of any building in the city, and if successful the city shall accept this "*pig in a bag*" and pay the hydrant rental etc. The first tests calls for six streams thrown to a certain height in still air; this tests assumes that conflagrations occur when the air is still; the hydrant pressure required is 44 pounds. For the two streams through 800 feet of hose, 65 pounds pressure at the hydrant is required. These tests were successfully made and the works accepted by the city. The city can never ask for them again. The franchise calls for no repetition of these tests nor is there any pressure guaranteed to the city at any time, present or future, during the life of the franchise, which runs for 25 years, and the franchise requires no test of future pipe extensions and guarantees no fire protection upon such extensions. So far as the efficiency of such tests are concerned, as a gauge of capacity and power, it would indeed be a poorly constructed plant that could not meet them, successfully: yet this is a fair specimen of the franchise most generally adopted by cities and towns in the West. A City Council when granting a franchise of this kind does so entirely upon its united knowledge of water works construction and capacity, which in most cases is none at all; here again the conservative element crops out and objects to the advice of competent engineering skill because it is to be paid for; they say they can save money by not employing one, perhaps so; and make the bargain without him; yet at the same time they do not object to paying for the services of a lawyer to look after the law points involved in the franchise; and often the law is invoked later on, after the franchise in is operation, to remedy the mechanical defects of the system that practically existed the moment the franchise was signed.

The franchise granted to a water company, by the City of Racine, Wisconsin, in 1886, contains many items of great utility to the city; it is a franchise in which the interests of the city are better protected than is generally the case in transactions of this kind. There are 35

miles of pipe and 350 hydrants, and over 300 gates of all sizes in the system; in the business portion of the city and where the manufactories are located, there is a gate placed on the hydrant connection, between the hydrant and the main, so that the hydrant may be repaired, when necessary, without interrupting the flow of water in the main. The mains are 24 inch, 20 inch, and 16 inches diameter. The only 4 inch pipe in the system are the hydrant connections. All hydrants have double nozzles.

The population of Racine is about 22,000, its area is 7½ miles, and has about sixty-five manufacturing plants. Regarding the required pressures from this system I will quote from the franchise.

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"The said works shall be so constructed that they shall be able to furnish a plentiful supply of water to said city and inhabitants for personal, domestic and manufacturing purposes, for the extinguishment of fires and conflagrations: that they shall be able at all times, without notice, to supply for an indefinite period—10 fire streams from any ten hydrants, each streams using 400 feet of 2½ rubber hose, with one inch ring nozzle, which streams shall reach a vertical height of 70 feet, and said grantee shall maintain at all times a pressure of water sufficient to give such streams." These 10 streams require a hydrant pressure of 53 pounds, which is the available static pressure derived from the stand pipe, and is the daily maximum pressure maintained by the works.

The second test, quoting from the franchise, is: "And said works shall be so constructed as also to be able (by direct pressure from the pumps, the stand pipe connection closed) to throw 20 streams from any 20 hydrants, each stream using 400 feet of hose and a one inch ring nozzle, to the height of 70 feet."

These 20 streams respectively, require a hydrant pressure of 53 pounds the same pressure required for the first or previous test; the number of streams are increased from 10 to 20, and water is supplied by direct pumping pressure: this test was adopted to show the capacity of the works to supply water in the out lying districts of the city, should two or more fires occur at the same time; each one of these twenty streams discharges 113 gallons of water per minute; or 2,260 gallons per minute in the aggregate.

To quote further from the franchise: "Also furnish six streams from any six hydrants in the system, each stream using 400 feet of 2½ inch rubber hose, and a 1¼ inch nozzle, under a pressure of 125 pounds at the hydrant as long as desired, and the said grantee, shall, upon an alarm of fire immediately apply said pumps and shall furnish the maximum pressure above mentioned within fifteen minutes after said alarm, if called for, by the officer in command of the fire department.

The city may cause said works to be tested once each year and to bear the same tests herein provided."

The works were completed and tested for acceptance on the 17th day of August 1887, each test was successfully maintained. At a hydrant, located 1¼ miles distant from the pump house, in an air line, (and farther than a mile and a quarter by the pipe line) the pressure was maintained at 136 pounds for over two hours. Each year following the acceptance of the works, the city has exacted the last test of 125 pounds pressure at the hydrant, from the Water Company and each time the test has been successfully maintained.

The exaction of this test of 125 pounds pressure at the hydrant, every year by the city, is in my opinion not only unnecessary, but is too severe a strain upon the pipe system. That a newly laid pipe system should be subjected to such a test is, as previously stated, a proper and desirable procedure. The franchise says, plainly: that this maximum pressure of 125 pounds shall be furnished whenever called for by the officer in command of the fire department; with this privilege always at hand and two other prescribed tests available, it does not seem necessary that the extreme test should be used excepting upon an emergency during a great fire.

Last April a fire occurred in Racine which demonstrated the great efficiency of the system under static or stand pipe pressure. The malt house of a brewery took fire; it was a brick structure with walls about 80 feet high and without windows, excepting a few small ones at the top. The fire attained considerable headway before the alarm was turned in: The fire department turned six streams, through different lengths of hose, upon the building and soon had the fire under control, so that no other buildings contiguous to the burning malt house were injured. The water supplied for these six streams was used under stand pipe pressure entirely; no call was made by the fire department for direct pump pressure.

Racine had four steam fire engines when the water works were completed. Two of these engines have since been sold and the remaining two are for sale, to use a naval expression concerning them, "they are now out of commission" and have been since August 1887.

A city contracting for a water system should insist upon conditions of capacity and power; without these essential conditions the city itself is liable to great and destructive fires; a system having small pipes and small pumps must be reinforced with steam fire engines to get efficient fire protection. To build a water works system for a second or third class city with the intention of maintaining steam fire engines in connection with the water system, is very much like building a large steam-ship and then building a tug-boat to tow it.

I do not think a city can afford to lay four inch water pipe, only

one good fire stream can be obtained from a hydrant located upon a 4 inch pipe line, and not them unless the most favorable conditions exist. The difference in cost between one mile of four inch pipe and one mile of six inch pipe is about $800, and a city can well afford to pay this difference of cost rather than lay four inch pipe and forever maintain two or more steam fire engines. It is commonly said "that hydrants are cheaper than rubber hose;" while the expression is not very explicit the principle involved is a correct one. In the season of 1890, while engaged in water works construction, the contractor of the work was laying 8 inch cast iron pipe at a total cost of 75 cents per lineal foot; at the same time the City Council purchased a thousand feet or more of rubber hose to use for testing the water system upon its completion, paying for the hose 94 cents per lineal foot. Never before did I realize that an 8 inch cast iron pipe, laid in the ground, was cheaper than rubber hose.

In conclusion I desire to say regarding pipe pressures in towns and cities, that I do not think it safe nor practicable to maintain high pressures for fire uses in our largest cities and supply consumers from the same pipe system, it can be done however if there are enough pumping stations and they are located at proper intervals throughout the system—but the pumps must be supplied with water and this would involve the laying of a separate system of supply mains, which brings the question back again to the starting point and adopting Mr. Chesbrough's idea of a separate system of large pipe and high pressures for fire purposes, the same as affirmed by the Officer of the Chicago Fire Department. Cities with a population of 60,000, or less can safely use one system that will answer all general purposes, but the system should be generously planned and well constructed.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

BOSTON SOCIETY OF CIVIL ENGINEERS.

SEPTEMBER 21 1892:—A regular meeting was held at Wesleyan Hall. Bromfield Street, Boston, at 8 o'clock P. M. Vice-President McClintock in the chair. Forty-five members and twenty-two visitors present.

The record of the last meeting was read and approved.

Mr. Joseph N. Drew was elected a member of the Society.

Vice-President McClintock announced the death of James B. Francis, a past president of the Society, which occurred September 18. 1892. Mr. FitzGerald spoke briefly of the life and work of Mr. Francis and of the interest he had always taken in the Society. He moved that a committee of three be appointed by the President to prepare a memoir of Mr. Francis, and it was unaminously carried. The President has appointed as the committee: Desmond FitzGerald, Joseph P. Davis and John R. Freeman.

Mr. A. W. Locke was then introduced and read a paper entitled "The Gradual Abolition of Highway Grade Crossings."

At the close of the reading of his paper Mr. Locke had thrown upon the screen a number of photographs taken during a recent trip abroad, illustrating the methods used there for abolishing and guarding grade crossings.

Mr. J. W. Ellis spoke of the work that had been done in Providence R. I. in the way of abolishing grade crossings and what it was proposed to do in Pawtucket.

Mr. A. F. Noyes gave an account of the various plans which had been considered for abolishing the grade crossings in Newton.

Mr. F. H. Snow spoke particularly of the method of procedure which had been adopted by the City of Brockton to solve the grade crossing problem in that city.

The discussion was further continued by Messrs. Turner, FitzGerald, Kimball, Brooks and Smith.

Adjourned. S. E. Tinkham, Secretary.

ENGINEERS' CLUB OF ST. LOUIS.

370TH MEETING, October 19, 1892:—The club met at 8 p. m. at the club rooms, President Johnson in the chair and twenty-two members and three visitors present.

The minutes of the 369th meeting were read and approved.

Messrs. S. L. Weil and E. J. Jolley were proposed for membership.

The by-laws were amended by inserting in Section 7, in the sixth line, on page 15, after "election": "except as provided for in Section 8," and by the insertion of a new section as follows—

SECTION 8. EXCHANGE OF MEMBERS—Any member of any other society in the Association of Engineering Societies, in good standing, may become a member of this club, when duly elected as described in Section 7, without paying the initiation fee, and with a release from the annual dues for such period, not over one year, as he may show by certificate he has paid in advance in the society from which he comes; provided such society shall have conferred like privileges on members of this club.

—And by renumbering the following sections in order.

Mr. W. H. Bryan then read the paper of the evening on "Steam Engine Efficiency: Its Possibilities and Limitations." Mr. Bryan called attention to the popular idea of steam engine efficiency, alluding briefly to failures which had occured in attempting to secure expected results from high efficiency machinery. He dwelt upon the ideal engine as distinguished from the real engine met with in every-day service, and showed that the perfect engine itself is of low efficiency on account of the narrow limits of temperature within which it is possible to work. But 30 per cent. of the heat units in the steam can be utilized, even by the perfect engine, working between ordinary temperatures; under which conditions but $2\frac{1}{4}$ pounds of steam per indicated horse power per hour would be required, if all the heat units in the steam could be transformed into work. The real engine is subject to still greater losses, and the limits of its efficiency were pointed out. The advantages of the multiple cylinder engine were shown, and a table, giving the results of a large number of tests of existing engines was presented. Comparisons were made of the amount of steam required in pounds per I. H. P. per hour for the actual as well as the ideal engine. From these results percentages of efficiency were presented in three forms: First, the efficiency which a perfect engine would have, working between the same limits of temperature, compared with the total number of heat units in the steam; second, the efficiency of the actual engine on the same basis; third, the relative efficiency of the actual engine on the basis of the number of heat units which it is possible to utilize within the given limits of temperature. Attention was called to the limits of pressure and the number of expansions desirable in single and multiple cylinder engines, as established by the best modern practice. The relation between the duty of pumping engines and the efficiency of ordinary engines in pounds of steam per I. H. P. per hour was also pointed out.

Discussion followed by Messrs. Olshausen, Seddon, Laird, Johnson, Perkins and Schlosser.

For the next meeting, November 2d, a paper on "The Recent Survey of St. Louis: Its Methods and Results," by Mr. B. H. Colby, was announced.

Adjourned. ARTHUR THACHER, Sec'y.

CIVIL ENGINEERS SOCIETY OF ST. PAUL.

NOVEMBER 9, 1892:—Regular meeting of the Society was held at 8:45 p. m., nine members present including President Woodman.

Minutes of the previous meeting were read and approved.

Committee on transportation for coming excursion to West Superior and vicinity reported a favorable arrangement and various details of the trip were discussed; a communication from the invitation committee of

West Superior Engineers with an outline of their proposed entertainment of the Twin City Engineers being first read. Thursday evening Nov. 10 was the date fixed for departure: a portion of the party to go by way of the St. P. & D. Rd., the remainder by way of the C. St. P. M. & O. Ry.

Various communications not requiring immediate attention were laid on the table aud an early adjournment taken.

C. L. ANNAN, Secretary.

WESTERN SOCIETY OF ENGINEERS.

295TH. MEETING, OCTOBER 5, 1892:—The 295th. meeting ot the Society was held at the rooms of the Central Traffic Association, The Rookery, Wednesdny evening. October 5th. 1892. at 8 P. M. President Randoplh occupied the chair and some 40 members were present.

The reading of the minutes of the last meeting was dispensed with.

The Secretary reported for the Board of Directors the following elected to membership:

Noah E. Stucker, Eric Swenson, Frederick K. Copeland, Edgar French, K. E. Hilgard, E. J. Pearson.

The application of Mr. William Steyh was placed on file.

The Board of Directors had also passed unanimously the following resolution:

Resolved, That the Secretary be authorized to tender, in the name of the Board of Directors, to Mr. James Dredge, of London, and his friends, members of the Society of Arts, or otherwise, the free use of the Society's rooms, and facilities for receiving their mail during the year 1893.

The president next called for the supplementary Report of the committee on "Badge, Seal," etc., which was ordered at the September meeting. This was presented by Mr. G. A. M. Liljencrantz, chairman of the Committee. The report was received by the Society and Committee discharged.

Mr. Thos. Appleton next presented a report of the Joint Committee on amendments to Constitution and By-laws.

A spirited discussion arose on a proposition of Mr. Artingstall to print and issue the matter as presented and await the next meeting of the Society before submitting it to the preliminary vote of the members present as provided by Article 6, of the Constitution.

A strongly expressed feeling prevailed that too much time is wasted at the meetings of the Society on such matters, and the fact was urged that to lay the question over for another meeting would carry it over into 1893, and thus defeat the object of the amendments to prevent a recurrence of the difficulties experienced last year at the annual election.

A motion to submit the amendments to letter ballot was amended so that the ballots should be returned with the amendments voted on by sections and was finally carried.

Mr. Thomas Appleton then read the paper of the evening on "Cedar Block Pavements," which was accompanied by specimens of used and unused cedar blocks.

The paper was freely discussed, and with the discussion will be printed in an early issue of the JOURNAL OF THE ASSOCIALION OF ENGINEERING SOCIETIES.

Adjourned JOHN W. WESTON, Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.

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REPORT UPON THE FIFTH INTERNATIONAL CONGRESS OF INTERIOR NAVIGATION.

BY DR. CADY STALEY, MEMBER CIVIL ENGINEERS' CLUB OF CLEVELAND.

[Presented October 11, 1892.]

Mr. Chairman: Of course you do not expect me to go into details concerning the themes discussed during the International Congress, but rather to give you a general idea of what took place. The first thing that impressed me was the consideration shown such conventions in France by state and municipal authorities, and the favors granted them by the railroad officials. The Congress was treated with the greatest consideration by the authorities in Paris, and in the other cities where the members went on excursions. The concessions granted to the members by the railroads were worthy of note. Notice was sent to members that arrangements had been made to lessen the cost of transportation, so, when I entered France from Spain I thought I would write to the Secretary of the Congress and see if I could secure any reduction in the fare up to Paris. When I reached Avignon I received a letter containing an order, on the presentation of which I was given a ticket to Paris for half fare. The same thing was done when I left for home. Members could go to Paris and return for half fare by any railroad in France which they might select, and they could go one way and return another. In short, the members of the International Congress were granted more favors by the railroad officials in France than I have ever known to be granted by railroad officials in this country to similar organizations. On the excursions, not only were arrangements made. for reduced fares, but the members were

royally entertained in the cities to which they went by the government officials and the scientific societies.

Excursions for the purpose of seeing notable works relating to interior navigation were a prominent feature of the Congress. Two long excursions, one in the North of France and another in the South, were so arranged that members could join them on their way to Paris, and at the close of the meeting two more long excursions were arranged so that members could take them on their way home. Excursions to points near Paris were made during the meeting. The session of the Congress extended from the 21st. to the 31st. of July. The meetings were held in the Palais de l' Industrie, where ample accommodations were provided for the general sessions, the meetings of the sections, and a magnificent collection of drawings and models. There were scores of models of locks, reservoirs, movable dams, lifts, dredges, traction machinery, and other engineering works connected with interior navigation. Some of these models were of notable works already constructed, and some of proposed works. Many of them had complete descriptions accompanying them. Most of the work of the Congress was carried on in the four sections into which it was divided. The papers presented were grouped under the ten following heads:

	SUBJECT.	NUMBER OF PAPERS.
1.	Canal Banks	3
2.	Water supply of Canals	2
3.	Traction of boats in Canals	2
4.	Reservoirs	4
5.	Stoppages on Canals	5
6.	Traction of Boats in Rivers	6
7.	Tolls on Inland Transportation	6
8.	Ports for Inland Navigation	3
9.	Respective uses of Water Ways and Railroads	8
10.	Improvement of Rivers	9

Most of the papers were descriptions of work which had been done, and an account of the results which had been accomplished. They were accompanied by the necessary illustrations to make the descriptions intelligible. The papers were printed in French, German and English, and were given to the members when the Congress first met. The papers were not read in the Congress, but, when they came up for discussion, the authors were called upon, and permitted to explain or enlarge upon any points in the paper. These remarks were given in French, German or English, as the speaker chose. Mr. George H. Ely of Cleveland, and Mr. E. P. North of New York presented papers and gave their remarks in English. If the remarks were in English or German, as soon as the speaker concluded, the Secretary would rise and give the substance of them in French. If they were in French,

the Secretary would give them in English or German, if any one requested him to do so.

Eleven different languages were spoken by the members, which shows the international character of the Congress. Every one, however, was expected to address the Congress in either French, German or English, and a large percentage of those present could follow a speaker in either of those languages. One could tell this by the interest evinced when telling points were made.

They printed a daily "Official Bulletin," giving a resume of the work of the congress day by day. I leave a full set of them here for the library of the Club.

MR. PORTER:—I would like to ask if Dr. Staley would infer from the interest taken in the meeting there, that the revived interest in canal and slack water river navigation is a permanent one, such as would put these canals in shape to compete in future with railroads, whether there was any prospect at all for being so successful as to induce any movement in this country towards the construction of more canals and works for river navigation.

DR. STALEY:—There are two reasons for the renewed interest in Interior Navigation. One is the cheapness of transportation by water, and the almost unlimited opportunity to expand on some lines of communication, as on the Great Lakes; the other is the advantage of water communication on certain lines in case of war.

I say renewed interest, because before the modern railroad building era, transportation by water was relatively of much greater importance than at present.

Since railroads have been so wonderfully developed, and their freight rates have been so marvelously cut down, the necessity for water lines have in many cases been removed, canals have in many places fallen into disuse, and communication by water has not received the attention it deserves.

The interest in Interior Navigation is growing, as is shown by this International Congress, and in this movement the necessities of national defense play no small part in all countries. The enlargement of the Erie canal is urged, not only on the ground of providing an outlet for traffic from the great lakes to the sea, but in order that gun-boats may also pass. The improvement of means of communication for military purposes is no new thing. The great Roman roads were built to facilitate the movement of armies. The first great road over the Alps was built by Napoleon to provide for the rapid transportation of his army into Italy. "When can the cannon go over," was his constant question to the engineers. And this renewed interest in interior navigation is intensified by the part it plays in the schemes for national defense.

On many lines the necessities of freight traffic alone is sufficient to account for the growing interest in developing the means of communication by water, especially in improving natural water ways, and in building, or enlarging, canals connecting bodies of water of considerable size. I do not think there is any tendency to build new canals on lines of limited traffic, but rather to improve water ways on lines of heavy traffic. With a light traffic canals cannot compete with railroads.

JOHN WHITELAW:—A MEMORIAL.

BY COMMITTEE OF THE CIVIL ENGINEERS' CLUB OF CLEVELAND.

At a special meeting of the Civil Engineers' Club of Cleveland, called on June 18th, 1892, to take appropriate action in relation to the death and funeral of our late member, John Whitelaw, the undersigned committee was appointed to prepare a memorial and resolutions, and submit the same at the next regular meeting to the Club for action thereon; pursuant thereto your committee beg leave to submit the following:

John Whitelaw, late Superintendent and Engineer of the City Waterworks of Cleveland, Ohio, was born in Cleveland, July 31st, 1831, and died June 16th, 1892.

Death has claimed a member of our Society, who ever since its organization in 1880, took an active interest in its proceedings and welfare. Mr. Whitelaw was our president for two terms, from March 8th, 1887 to March 12th, 1889.

The deceased was a gentleman of sterling integrity, esteemed and loved by all who had the privilege of calling him a friend. His kind and suave manner, be it in friendly intercourse or in earnest business transaction, will ever be remembered by all who came in contact with him.

While possessed of great experience and a thorough knowledge of his profession, he was ever modest and unassuming in his ways.

Mr. Whitelaw attended the public schools of Cleveland and studied later Civil Engineering with John Shire, a noted Engineer and Surveyor of Canada. In 1857 he entered the office of the City Civil Engineer as assistant, was appointed City Civil Engineer in 1859, and again in 1860, but resigned and engaged in contract work with James Howells, of Buffalo. In 1861 and 1862, he was again in the employ of the City, part of this time as Engineer and part as Assistant. Resigning his

position, he went to Canada, where he remained at the former home of his wife till 1864.

Returning to Cleveland, he was again appointed City Civil Engineer, and held this position till 1867; his resignation being accepted, he was appointed Superintendent and Engineer of the Waterworks, which office he held continuously until the time of his death.

During the 25 years Mr. Whitelaw was connected with the Cleveland Waterworks, the growth of the same kept steady step with the growth of the City. From a comparatively small plant supplying the wants of but 80,000 inhabitants and few factories this system has steadily increased and is now furnishing over 300,000 people and all the extensive manufactories of our growing City with an abundance of water.

During the superintendence of Mr. Whitelaw, a great number of improvements were introduced in the plant of the Waterworks. Some of the most important are, the crib located one and one-quarter miles from shore in 38 ft. of water, connected with the pumping station by two brick tunnels under the bottom of the Lake, the first completed in 1874, of 5 ft. diameter, the second, in 1890, 7 ft. diameter.

The pumping machinery consisted in 1867 of only one double Cornish Pump of a daily capacity of about eight million gallons, and comprises now six pumps of a total daily capacity of 70 million gallons, while the original Cornish pumps do duty at the high service station at Fairmount St., which was erected during 1884 and 1885.

Two reservoirs were built in connection with this station, one situated at Fairmount St. of about 80 million gallons capacity, and one at Kinsman St. of 40 million gallons capacity; the first 170 ft. and the second about 325 ft. above the level of Lake Erie.

All these improvements will remain as lasting monuments of the ability and integrity of the late John Whitelaw, who has planned and executed them.

Resolved, That the foregoing memorial expresses the unanimous sentiment of the members of the Civil Engineers' Club of Cleveland.

That we mourn the loss of our fellow member in his best years of ripe manhood.

That our sympathy is with the bereaved family.

That we ever shall cherish an affectionate recollection of the high qualities of our departed member.

That the memorial and resolutions be spread upon the minutes of the Club.

That the same be published in the JOURNAL of our Association and a copy be presented to the family of the departed John Whitelaw.

Committee: L. HERMAN, M. W. KINGSLEY, M. E. RAWSON, CHAS. H. STRONG.

HISTORICAL SKETCH OF STORAGE BATTERIES.

By C. F. Uberlacher, Before Civil Engineers' Club of Cleveland.

[Read October 11, 1892.]

I will not attempt to enter into any scientific description of the various forms of storage battery, of the chemical reactions thereof, or of the theoretical determinations of the energy in such cases. Such questions are properly within the scope of a paper before this Club, but as I have had no occasion or opportunity since my college days to refresh my memory on this subject, I must beg your indulgence for a paper treating only on the historical and practical side of the question.

In order to be able to form an idea of the patents and points at issue, we will begin with an explanation of a simple storage battery. I cannot do better here than to give Judge Coxe's definition, laid down by him in the suit of the Electrical Accumulator Co. vs. the Julien Co. "A secondary battery is one which gives no electricity of itself, but is active only when rendered so by a current from an independent source." You will find the terms storage battery, secondary battery and accumulator used indiscriminately. There is, properly speaking, a distinction between them, but as it is seldom observed and will take some time to explain, we will pass it over.

The simple storage battery consists of two plates immersed in a fluid, which under ordinary conditions does not attack them, and electrically insulated from each other. Let us take the most common form of storage battery as an example. The two plates are lead, (preferably cast). The fluid, technically termed the electrolyte, is $^{9}/_{10}$ parts water to one of sulphuric acid. The jar containing the whole is glass. Normally the sulphuric acid does not attack the lead plates, but let a current of electricity from an external source be passed through the battery, entering at the plate marked × and leaving at the plate marked — and there will be hydrogen given off at the — plate and oxygen at the × plate, due to decomposition of the electrolyte by the current. The hydrogen has no effect on the lead of the — plate, but the oxygen given off at the × plate attacks the lead and forms lead oxide.

If now, we reverse the direction of the charging current, letting it enter at the — plate and leave at the × plate, we will have oxygen given off at the — plate and hydrogen at the × plate. At the — plate the oxygen will attack the lead and form lead oxide, while at the × plate the hydrogen will combine with the oxygen of the lead oxide, previously formed, to make water, and will leave what was a coating of lead oxide, a spongy, porous mass of lead.

If, now, after this second charging, (as the passing of the current from an external source through the battery is called), we connect the two plates together with a conducting wire, they will cause a current to flow from the × plate to the — plate, or in a direction opposite to that of the last charging current. During the continuance of this discharge, as it is termed, oxygen will again be given off at the × plate, combining with the spongy lead there an oxide of lead termed minium, and hydrogen will be given off at the — plate, reducing the oxide there to spongy lead. The discharge will continue until the coating on the plate has been reduced to about half and half spongy lead and oxide by the combination of the hydrogen given off by the electrolyte and the oxygen from the oxide of lead, and the coating on the × plate has been raised to the same condition, i. e., half oxide. When this stage is reached the discharge will cease and the battery must be recharged from an external source before more can be obtained.

The duration and quantity of the discharge will be proportional to the depth and size of the spongy lead and lead oxide coatings.

The above is the first commercial form of storage battery, and was invented by a Frenchman, Plante. The patents of Faure, Brush, Julien and most of the others are simple improvements upon this type, using practically the same materials and differing in the mode of construction.

There are several other types of storage battery but none of them have obtained much commercial prominence. The best known of these is probably Alkaline storage battery, using one zinc and one porous copper plate in a solution of caustic potash. There are several patents on this type, principally those of Reynier in France, and Desmazure. Entz and Phillips in this country. You will notice that this battery falls without Judge Coxe's definition, as it would furnish current before being charged from an external source. The charging simply regenerates it, or restores zinc to the zinc plate and oxygen to the porous copper. It is a storage battery but not a secondary battery.

Faure, 1878, in France, conceived the idea of dispensing with the long and expensive forming process of Plante by applying a layer of oxide of lead to the lead plates instead of producing it upon them by electrolyte action. In the Summer and Fall of 1878 he made a few experiments in this line, and, running across some difficulties, gave it up. In Faure's first experiments in 1878 he held his layer of oxide upon sheet lead plate by wrapping felt around both. This was also the idea with which he started in, early in 1880, but he soon abandoned it for a grid somewhat similar to those now in use.

In 1879, Brush patented his "gas Battery Arc Lamp," using a form of storage battery which has never become of commercial value, and

then hearing of Plante's work began experiments in the same line. The first idea was to improve upon Plante's battery and he began work with rolled lead plates. He soon, however, discovered the cast plates were preferable, and from this point he went on to get a soft, spongy lead plate formed by chemical means. His first idea being to force a cloride of lead into the grid, and then lay one of these plates in dilute sulphuric acid with a sheet of zinc with a metallic connection between them to allow the electrolyte current generated to reduce the chloride until it left only a spongy mass of lead. The idea then occurred to him of applying the active material direct to the plates by a coating of minium or litharge on sheets of lead, supporting it by blotting paper.

His next arrangement was a rolled lead plate deeply groved by gang saws, and in these groves he forced the oxide. His first practical battery, one which he used for lighting his house early in the 80's, was however of the Plante type, the plates being cast in moulds which gave them the same form as the sawed plates and then being formed by the regular Plante method of charging and discharging.

In the mean time Faure in France, had again begun experimenting in 1880, and had, in 1881, applied for a patent in the United States with which Brush came into interference. Some of Brush's patents were granted immediately, but the principle one was put in interference with Faure and three others. This interference was hotly contested for four years, but Brush was finally, in 1886, granted the broad patent substantially according to his original claims and Faure's patent made subservient to his.

The principle claims in Brush's patent were the combination of the active material and a supporting grid, and the mechanical application of the active material to the plate or grid.

Faure's patent was made to cover the application of the active matter to the plate in the form of a paste, paint, or cement (a very important item, by the way, as it is exceeding difficult to make a successful plate by applying this active matter dry.)

Julien's patents began in 1886. They are for an alloy of lead, antimony and mercury for the grid, also the form of the grid and various parts of the process of manufacture.

In addition to these there are other inventors without number, who hold patents of more or less value. Swan and Selon of England had patents on the form of the grid, which have figured in the suits, also on the alloy of lead and antimony. Gibson, of New York, holds valuable patents on the method of construction, as do Knowles, Pompelly and a score of others.

So much for the patents, now for the companies formed to manufacture under them. The Faure and Brush interests were the first to

be exploited. In 1883 a battery of Faure cells was brought to this country from France, and almost immediately the Electric Storage Co., of Baltimore, was formed to perfect it, and rights were secured by A. G. Davis, and by him transferred to the Electric Storage Co. The Electric Storage Co. did their experimenting and manufacturing at the works of the Viaduct Co., Baltimore, where they had quite an extensive manufacturing plant. E. H. Bauer was their expert.

About this time the Anglo-American Electric Light Co., was formed in New York, also manufacturing under the Faure patents. Soon after this the Electrical Accumulator Co., was formed, having its headquarters at New York and works at Newark. This company manufactured under the same patents as the Electrical P. S. Co., of England (i. e., Faure, Selon, Swan, Shaw, Rogers, etc.,) and was virtually an offshoot of that company. All the Faure interests in the United States were soon merged into the Electrical Accumulator Co.

In the mean time Brush was still experimenting and the Brush Co. was manufacturing and putting batteries on the market.

In 1885 or-6 the Julien Storage Battery Co., of New York, was organized to manufacture under Julien patents (this Julien Co., has since deen reorganized under the title of the Consolidated Electric Storage Co.,) and it is between these three companies that the most valuable and fundamental patents are held, and most of the litigation has arisen.

The suits instituted have been very numerons and bitterly fought. The first important one was a suit for infringement and injunction instituted by the Electrical Accumulator Co. vs. the Julien Co. They sued on four patents: three of these were found valueless, and the fourth, that of Faure, they were compelled to limit to claims covering the application of the active matter in the form of a paint, paste, or cement, and the Julien Co., was enjoined accordingly.

At the same time the Electrical Accumulator Co., instituted a suit against the Brush Co. in Ohio, but abandoned it when the court recognized Brush's claims as predominant in the suit of the Electrical Accumulator Co. vs., the Julien Co.

Then followed the Brush Electric Co., vs. the Julien Electric Co., for infringement of Brush's patents. Some of Brush's claims had to be abandoned, but the main ones were upheld by the court.

The last suit, on which decision in favor of Brush was rendered last week which has recently been argued in the United States Circuit Court of Appeals, was the Brush Electric Co., vs. the Electrical Accumulator Co. This suit was first brought in April, 1887, and was finally decided in favor of the Brush Co. in July, 1891. The Electrical Accumulator Co., being bankrupt, all damages were waived and only an injunction taken out. (Injunction principally restraining the Electrical Ac-

cumulator Co., from the mechanical application of the active material to the plates.)

The types of storage batteries are as numerous as the inventors. Reynier classifies them under four heads, viz., *A*, those having two lead plates and sulphuric acid diluted as an electrolyte; *B*, those having plates of lead oxide for the positive and copper for the negative, and sulphate of copper for the electrolyte; *C*, those having lead positive and zinc negative plates and sulphate of zinc for the electrolyte: *D*, those having porous copper for the positive, iron for the negative and sodium or potassium zincate for the electrolyte.

Of these the first type is by far the most numerous, as lead seems to be the metal easiest oxidized and handled, and is practically insoluble in the dilute sulphuric acid. No end of ingenuity has been expended in the formation of the grids or plates for these batteries. As before mentioned, Plante's original idea was a small rolled lead plate, upon which he formed oxide by continually charging and discharging. This operation occupied from four to six months before the battery was in commercial shape. Faure's original plate has already been described.

The great difficulty found by the inventors of this lead battery has been the expansion and contraction of the active material as it became oxidized and deoxidized. Swan and Selon, in England, were probably the earliest inventors attempting to correct this by the formation of the grid. Their principle idea was to divide up the mass of active material into such small quantities that their contraction and expansion would not loosen them from their hold upon the supporting plate.

After them have followed a whole host of other inventors with the same idea in view. I will give sketches of a few of these ideas. Faure's first scheme was a small square hole, then followed Swan and Selon with a hole smaller in the center than at the two surface openings. Gibson, of New York, made capsules of his active material and inserted these in holes in his supporting plate, afterward passing the plates through a pair of rollers and so burring the ends of the holes over upon the active material. Another scheme was to put the active material in the form of pencils in a grooved plate and then bend the edges of the groove down upon these pencils of lead oxide. Still another was to fill a perforated lead tube with active material, and afterward bend this into the form of a plate. Inventors following Plante, tried also schemes of every description to make a plate of finely divided lead. One idea was to take lead wool, or spun lead, and tie it in bunches with lead wires. Brush's moulded and sawed plates come also under this head. A Denver inventor made a combination of lead, zinc and silver, from which he cut out the zinc by a chemical means. The Woodward people, of Detroit, cast lead and salt together, afterward dissolving out the salt, and so getting a porous plate.

Probably the neatest scheme for this was a modification of Brush's chloride idea. Under this method the cloride was fused and cast into small double convex discs: these were then cast into the lead plate and reduced by the same method as employed by Brush.

Eikemyer, of Yonkers, placed side by side plates of insulating material and cast lead with corresponding holes drilled straight through from one end of his cell to the other. The holes in the lead cast plates were recessed, and the active material forced into these recesses.

The Ford & Washburn battery, of which you have all probably recently heard, belongs under this head. It has a very ingenious device for doing away with the trouble caused by expansion and contraction, and consequent loosening of the active matter. It consists of a thin porous earthenware cup inside of which is placed a hollow lead plate, allowing a space between the plate and cup; outside also is placed a perforated lead cup, allowing some space between it and the earthen ware cup. The space thus left inside and outside is filled with the active material which forms the two plates of the battery. The hollow lead plate inside is supposed to allow for the contraction and expansion of the active material. It can readily be seen that short circuiting cannot take place in this battery unless the earthenware cup should break. This is probably the latest attempt to produce a battery suitable for street railway work, and it is sincerely to be hoped that it will be successful.

Of Reynier's class *B* there are very few specimens, and none of them have reached commercial account. They are practically primary batteries which are regenerated after becoming exhausted.

The same can be said of class *C*, those having a lead positive and zinc negative plate with sulphate of zinc as an electrolyte. The principal trouble with this battery has been that it loses its charge when standing on open circuit.

Class *D*, has been exploited by several Frenchmen, principal among whom is Desmazure. His battery consisted of a porous copper positive plate produced by moulding granulated copper under an enormous hydraulic pressure and covered with parchment, and tinned iron wire gauze negative. The electrolyte was potassium zincate. The oxide of copper formed would dissolve quite readily in the electrolyte, but did not dyolize to any appreciable extent. This was the battery used on the famous torpedo boat, Gymnote, in the harbor at Havre.

Waddell, Entz and Phillipps have introduced a very similar battery in this country for street railway work. Its advantage is that it is considerably lighter than lead batteries having the same storage capacity, but it is liable to lose its charge on open circuit due to the formation of what is technically known as "zinc trees" on the iron plate. They obtained very fair results from this battery in railway

work for a time. but the last I heard of their car it was side-tracked at Chester. Pa., and no work was being done upon it. We certainly hope that this does nor mean a total failure of their scheme.

Having given a partial review of the different forms of batteries which have been put upon the market. I will now proceed to treat some of the difficulties which lie in the way. I have already mentioned the expansion and contraction of the active matter in the lead batteries, and the consequent loosening from the grids or plates. Plante ran up against this trouble very early and attempted to get around it by making his plates smaller, but even with small plates he frequently found that when the porous lead or oxide coating reached any depth at all it would crack and fall away from the solid lead entirely.

In my personal experience, however, the battery which gave the best satisfaction, was the old Plante type with plates about 12″×14″. This run along for six or eight years with no more attention than an occasional refilling.

Swan and Selon's idea of dividing up the active material on the plate has also been mentioned. With all the ingenuity that has been expended upon the supporting grid, it has been found that the active material forces itself out. the force in some cases seeming to be almost of an explosive nature and producing radial cracks on the active material. The plates of the battery are all placed close together in order to reduce, as far as possible. the ohmic resistance, so that this disintegration, or loosening of the flakes makes a contact from one plate to the next, so short circuiting two of the series. and occasioning very rapid deterioration of the whole cell. The ohmic resistance of the electrolyte is another source of loss, and this is probably the only one which can never be obviated. It is, however, of very small account. as it in no way injures the life of the battery. Another trouble caused by the expansion and contraction of the active material is the so called buckling of the plates. Expansion taking place unequally on the two sides causes the lead grid to bow out and so come in contact with the next one in the cell. What is technically termed sulphate (?) is usually the occasion of this. This sulphating is the forming in a battery when left uncharged, or even if left standing in any condition without use for any length of time, of a white sulphate of lead. which is practically insoluble in the dilute sulphuric acid. and it is at the same time a very good insulator. so that portions of the active matter becoming covered with it become inactive.

This on charging and discharging increases the ohmic resistance of the battery and at the same time decreases its capacity in proportion, also occasioning the injurious buckling.

Lead is at the present time the only material which experimentors have been able to oxidize and deoxidize successfully. It can readily

be seen that this necessitates a heavy weight for the battery, as lead is one of the most easily oxidized of all the metals, and so requires a large weight of material to store a given amount of energy. Lead grids have also been used almost exclusively for the support of this active material. This again brings in the element of weight as does also the use of fluid electrolyte.

Storage batteries are also liable to the trouble of local action, the same as are primary batteries. Local action takes place between two portions of the same plate whose chemical conditions are different, and produces the same effect on the rest of the plate as though the battery were partially short circuited.

To all of these troubles must be added another, and probably the most serious one, that of incomplete chemical change on charge and discharge; this is probably the root of most of the others. It is well known to all of you probably that chemical action is liable to differ considerably under slightly varying conditions of temperature and surroundings, so that chemical actions are liable to be different in two parts of the same plate. The appearance of white sulphate is probably due to this cause. It forms not only when the battery is standing idle, as above mentioned, but also when the cells are subjected to a rapid charge or discharge.

Another difficulty with the storage battery is in the bubbling and evaporation of the electrolyte. The spray thrown off in rapid charging and discharging is liable to form a conducting film over the jars and supports of the battery, so short circuiting it, in addition to necessitating frequent replenishing of the fluid. The fact that most batteries are supplied with a fluid electrolyte also makes them inconvenient to transport gelatine, grease, straw, etc. All of these troubles together seriously reduce the efficiency of the storage battery. Working at its most efficient point, viz., that of slow charge and correspondingly slow discharge, the storage battery seldom reaches an efficiency of 80%; on the discharge being rapid the efficiency is apt to drop below 50%, and as these are the conditions met with in most of the services which the accumulator is called upon to perform, we cannot safely consider its average efficiency as higher than 65 or 70%.

The idea, however of the storage battery is an inviting one. From the time of its first invention and even the time of its first discovery it has not lacked either inventors to experiment with it or capitalists to furnish the funds for manufacture. It is used far more abroad than in this country. The house to house system in England is probably the only strictly storage battery system at present in existence. Their plan is to place in each house, or in each center, a battery which is charged during all of the 24 hours and discharged according to the commercial demand for light or pow-

er in that district. A very similar scheme was exploited by the Brush Co., some four or five years ago. Mr. Roberts, the Chairman of your Electrical Section, is probably much better able to give you a few interesting details of this system than I am, as he had charge of the Brush Co's largest plants, of this nature viz., that at Cheyenne.

The accumulator can be used to great advantage in central stations as an adjunct to the dynamo plant. It is placed in shunt, across the main leads from the dynamo. When the load is small the potential at the terminals of the dymano is high, thus causing the current to pass through the storage batteries; when the load increases beyond the capacity of the machines the potential at the terminals of the dynamo falls and the storage battery supplies current on the lines, thus helping out the machines: or, the dynamo plant may shut down entirely when the load is light or in case of accidents, leaving the storage batteries to supply the whole demand. This evens up the load on the machines very much and considerably increases the efficiency of the plant aside from requiring a very much smaller original outlay in machines and engines. This same idea has been introduced to some extent in railway stations abroad. It assists greatly in checking rapid variations in load experienced in that work, and renders the use of compound engines advantageous where it would be impossible to employ them other wise.

A great advantage of the storage battery is that it can be charged any time when power is handy, and from then on for the next two weeks is in shape to restore a large percent of the power put into it. It comes in very handy, indeed, in stations where the source of power is intermittent and where lights or motors are wanted at times, and where energy from the main source is not obtainable. In street railways it of course gives the advantage of independent units: a breakdown of one car can never disable the entire line. This advantage was realized almost as soon as the storage battery came into prominence abroad, and as early as in 1880 experiments were made in London and Paris for the propulsion of vehicles. In 1883 a car on Kew bridge was operated with accumulators and run for some time very successfully, but the wasting away of the positive plates soon ate into too much money and the scheme was abandoned. The Julien cars on 4th avenue, New York, also ran very successfully for over a year. Their operation was, however, hindered by the out-come of certain suits. In addition to this difficulty was found here, also, with the positive plates.

New Orleans, until recently, had quite an extensive storage battery system, but it has been at last abandoned. The only two roads in regular operation are those at Milford, Mass. and Washington, D. C. Until recently one was in operation at Dubuque, Iowa, but it has been

thrown out for the trolley system, as the batteries were not found at all satisfactory. In Washington, where the trolleys are forbidden by strict law, the Edso Co. is now trying to operate a storage battery system under certain contract guarantees as to cost. Their contract called for the road to be turned over at the end of the first year, and the apparatus to be refused or accepted, according to the results, at the end of that time. Their first year of operation recently ended, and I notice that their time of grace has been extended another year.

The ordinary scheme in street railway work is to place the storage batteries under the seats of the cars, the cars in some instances being widened out to admit them. Various devices are in use at the charging stations for the easy removal and replacing of these batteries. Some companies prefer to remove them from the sides and others from the ends. Probably the best scheme for this purpose is an elevator arrangement, up to which the car is run and the batteries slid out on rollers onto shelves, where they automatically connect themselves for recharging.

The storage battery presents very pretty possibilities for regulating the speed of cars without loss of energy, by altering the connections of the cells so as to vary the potential at the terminals of the motor without the use of a rheostat. The most serious difficulties encountered are those of the jarring out of the active material, the rapid deterioration of the positive plates when subjected to a heavy discharge frequently met with in railway service, and the additional weight which has to be carried by the car up and down grade. The rapid discharge decreases the capacity of the cell very materially, so that a car that would, under ordinary conditions, run 50 or 60 miles with one charging, if called upon to perform extra work in the course of its trip is liable to become exhausted at the end of 30 or 40 miles, and will then have to be pushed in by the next car coming along. For this reason the disabling of cars has occurred quite as frequently on storage battery roads as on the trolley system.

The weight of the ordinary storage battery is from 100 to 125 lbs. per horse power hour carried. At the speed generally run one horse power hour is sufficient to carry a loaded car over one mile of track, of course not taking into account the grades. One can easily figure from this the amount of extra weight introduced by the use of the storage battery. Say that a car is designed to run sixty miles on a single charging it would neccessitate about three tons extra weight. As a matter of fact it has been found possible by lightening the cells and cutting down the quantity of electrolyte, to get the batteries as light as 50 or 75 lbs. per horse power hour, but these light batteries have been found to deteriorate so rapidly, that their use has been discontinued.

The Wadell-Entz iron and copper battery mentioned above is also considerably lighter than the standard lead cells: it weighs probably about 60 lbs. to the horse power hour and its life is not injured by this decrease in weight. I find even with these lighter batteries, however, that the increase of power required to climb grades practically rules out the storage battery car in hilly country. A short calculation will show that the extra weight carried on the storage car would increase the HP required to run it up a grade at about 8 miles per hour, at the rate of about one HP per cent of grade. This of course would, on 6 or 7% grades be a very serious disadvantage.

On the other hand we have the advantage of having no overhead construction to build or maintain to shock the esthetic tastes of citizens, and the station is always run at an approximately constant load, thus obviating the tremendous strains upon the engines and dynamos, as well as increasing the efficiency of both dynamos and prime movers.

In Brussells the storage battery was abandoned about two years since and the road returned to the use of horses. They found that the cost of the battery renewal amounted to about 2.75 cts. per car mile; at Dubuque it was claimed that the cost amounted to as high as 7.22 cts. per car mile, but this was probably excessive. The life of the positive plates is generally from 200 to 300 days in railway service, but the negative plates are comparatively indestructible. We have yet to find a storage battery that can even approach the condition of being commercially satisfactory. In situations where the loss occasioned by charging and discharging is not commensurate with the advantage of having a source of power always ready, the better forms of storage battery, with careful attention, give good satisfaction. The accumulator of to-day, however, will not take care of itself, and will not operate successfully except when in the hands of some one thoroughly accustomed to its peculiarities.

DISCUSSION.

Mr. Roberts:—As a prelude to what I have to say in the way of discussion I would like to state that I am chairman of the electrical committee. I gave every engineer an opportunity to prepare a paper for to-night and they all stated that they were extremely busy. Finally I got Mr. Uberlacher who is not a member of the Club, to prepare a paper and as usual the man who prepared the paper is one of the busiest men around. Mr. Uberlacher dictated it last night and received his copy this evening just before coming down. For that reason I think we should the more appreciate his kindness. I am also glad to state that he has signified his intention of allowing me to make an application for membership in his behalf.

To come to the paper itself, he has told us about a great many phases of the storage battery, and more especially with reference to street car work, and in a mild way has signified a desire to have me say something on the application of the storage battery to lighting. In the first place with reference to that, I want to point out one or two of the difficulties. The first great trouble in the storage battery is that the electro motive force at charging is about 2¼ volts per cell, whilst in discharging it comes down to 2 volts and shortly to one and nine-tenths. In incandescent lighting it is necessary to have constant electro motive force. Unfortunately the battery drops in voltage. Also there seems to be line loss of generally not less than three per cent. at full load, and therefore when at light load, the line loss being practically nothing, the lamps are strained to that extent, and moreover this is aggravated by the fact that the time of light load commencement is when the electro motive force is 2 volts per cell giving 5 per cent. more voltage than they give when the battery has reached its normal condition. Another difficulty arises from the fact before mentioned that 2¼ volts per cell is necessary when charging, therefore if it be desired to turn on lamps whilst the battery is being charged, it is necessary either to insert resistance in the lamp circuit or to use fewer cells for the same. This can be accomplished automatically but it is extremely difficult to construct batteries which can always be relied upon for this purpose and which shall not need more or less constant attendance in the way of inspection, adjustment, etc. Probably the best arrangement is to have merely an automatic device which will cut out the lighting circuit whilst the battery is being charged.

I might say there are three general plans for using the storage battery for lighting purposes. The first is locating the battery at the power house. The second is locating them in sub-stations which are the center of distribution for a small district. The third is locating them in each building where light is desired. The first plan has the following advantage, the electro motive force on the line can be controlled the same as it would be if dynamos were operating. The batteries are under constant inspection and it is somewhat easier to keep constant load on the engines than when using the second or third plan. The second plan has some of the advantages of the first and some of the disadvantages of the third. It is, as it were, a half-way point between the two extremes. The third has the disadvantage that is necessary to install a large number of cells in each house in order to supply the maximum output ever required which would probably be ten times or more the average output. The first plan is therefore most desirable when the lamps are not situated too far from the station, the line loss in such case being a large factor. The second plan can be resorted to when the lamps are at a great distance, therefore current can be sent

over the line at a higher electro motive force than would be used for the lamps if the batteries were charged in series. The third plan is seldom if ever advisable.

One great advantage obtained by using the storage battery is that engines can be kept on their most economical load all the time whilst operating and this is especially advantageous while using compound engines. In large stations in using batteries there are generally so many engines that the same result can be accomplished, but in a smaller station having two or possibly three engines, it is probable that for a considerable portion of time one or two engines will be operating under a very light load and consequent inefficiency.

The batteries can be charged either from a constant potential and varying current system, or from a constant current and varying potential. The first is used when the batteries are grouped together in the station or if they are located at not too great distances from the station and it be desired that the same dynamos should furnish current direct to the lamps when the batteries are not in use or it may be worked in conjunction with the batteries at the times of heaviest load. If however, the lamps are at a great distance from the station the second system can be used and arc light dynamos be used for charging and the line loss will be very small. This was the system exploited by the Brush Company and as far as reducing the line loss is concerned is equivalent to the transformer method used with alternating currents.

One trouble with the third method before mentioned is that the charging current is of such high electro motive force that it is not safe to have the batteries connected with the house wires when the battery is being charged. Automa devices to disconnect the house wires are therefore desirable but owing to their uncertainty it is probably better to have the necessary switches.

MR. BARBER:—Mr. President: as Mr. Uberlacher is not a member of the Club and as he soon will be, I rejoice in the opportunity that we have of offering him a vote of thanks.

MR. RICE:—Mr. Roberts: I happened to meet an electrician in the early part of the summer who made the statement that he had looked over some work in this city and that he believed it to be the worst system in the country; the most careless in putting up wires. I ask if this is a fair criticism of the work or not? He was an outside electrician.

MR. ROBERTS:—I do not wish to make any statement. There certainly is some very bad wiring in town.

MR. LELAND:—Did I understand that the paper read showed that the storage battery is no good? That is the conclusion I have drawn, perhaps I am wrong.

MR. UBERLACHER:—I hardly think we can say that the storage bat-

tery is no good whatever. The positive plates in use in the storage battery will give out in the course of a year or two even with careful handling; that is commercial batteries as manufactured to-day. They give satisfactory service until the active material becomes worn out. You must have a man who thoroughly understands the working of the battery,—a practical man.

MR. LELAND:—The inventor must go with each car.

MR. UBERLACHER:—Very near it, yes.

MR. HERMANN:—I have been told that the only successful storage battery road is in Milford, Mass.

MR. ROBERTS:—I think there is no question that the storage battery can be used and be relied upon to furnish current. There is a sufficient quantity, provided that the batteries are charged enough, so that they will never be over-discharged; provided they are very seldom over-charged; provided that when the cell commences to show signs of sulphating it is doctored and provided a good many other things. If a person can do that and does not care for the cost, he can obtain a reliable light. We use the storage battery in our factory. They are under a man's inspection. They do not cost very much but that is a very different thing from commercial lighting. If you are going into competition with a gas company, it has so far in this country proved inadvisable.

MR. PALMER:—I would like to ask if they are not used in mines somewhat?

MR. UBERLACHER:—I saw sometime ago an idea of a mining lamp, a portable mine lamp in which the storage battery was contained in a case small enough to be carried about. That is the only case of its being used in mines that I know of.

MR. BARBER:—I think there is one fundamental trouble with the storage battery. I think it never has been that any storage battery ever invented has had the principle of overcoming that trouble, and that is when the battery is charged and discharged and charged again it does not return to its former condition. There is a difference, there is a deterioration that takes place every time. It is simply a question of life. Of course that is very slight in the best batteries, but that of itself alone is almost fatal to the battery.

MR. ROBERTS:—With reference to that, the battery will continue to improve for a certain length of time because you are getting more active material. Of course it is leading to its death because the active material is being produced from the skeleton frame-work, which is therefore being weakened and by and by there is no skeleton framework left. The matter of sulphating has been touched upon pretty thoroughly in the paper. When the battery stands it becomes so badly sulphated in the multiple arc system that it is impossible to charge

it as a whole because the resistance is very high. It would be necessary to cut in cell after cell. I have seen considerable trouble in starting with 3,600 volts.

Mr. Ramsay:—I would like to ask if you know about that railway at Milford, Mass. I was interested in an article in regard to it. I do not know what the article cost. It spoke of it as quite a success.

Mr. Uberlacher:—I am afraid I cannot give very much information about it, as I have never seen any account of it. The road at Milford, Mass., was noticeable only from the fact it is one of the few roads that are running in this country. A road at Washington was put in by the Edso Co. They guaranteed at the time of installing it, to run it so that the cost of motive power should be eight cents per car mile, not including the other costs on the road. It was to be turned over at the end of a year and accepted or refused according as the books showed that the cost was less or more than the amount required. The cost at the end of the first year was somewhat more than eight cents. By some hook or crook they got a year's extension to go on and perfect the road. I presume we will have the storage battery running in Washington if they are making any progress.

Mr. Roberts:—The question arises as to whether the storage battery is of any use. It is used in Germany in connection with electric light stations. The conditions in Germany are somewhat different from what they are here. The storage battery can be used as an auxiliary. It seems it must be commercially advisable over there or they would not use it. They possibly have better batteries than we have here. The cost has been considered very carefully and so far it has not been considered advisable to adopt them. In earlier times in light stations there were a great many breakdowns. At present however the probability of a breakdown of sufficient extent to interfere with the general lighting is very small, hardly considerable. If you have a sufficient number of engines there is very little probability of any serious breakdowns. That was one great reason for exploiting the battery in connection with stations. From 1883 to 1885 or 1886 the Cheyenne plant was used with the battery in different places and then for two or three years they were grouped in the stations and used for day lighting in the winter time from 9 a. m. to 5 in the afternoon and in the summer time from 5 in the morning to 6 or 7 in the evening. The batteries would be charged from 11 or 12 at night until morning and engines which were in use were always operating under economical load. It would never have paid if we had to buy batteries for that purpose. These batteries were on our hands because the system had not been a success and having them it paid to use them.

Mr. Hermann:—The reason why the storage battery is better in

Germany is that good electricians are cheaper and probably more plentiful than here.

MR. ROBERTS:—I might suggest that Mr. Wason who is in the rear part of the room tell us something about storage batteries.

MR. WASON:—In connection with street car work in my private opinion the storage battery at present is further from a success that it was ten years ago. The manager of the road in Dubuque Iowa, stopped off at our city to look into our trolley systems with the object of equipping his road which was at that time attempting to be run by the storage battery. Everything in connection with the station, equipment, handling of cars was absolutely after the plans of the accumulator company or the storage battery company, managed by them and I suppose experts on each car were sent out. Notwithstanding the care taken to operate these cars [I think they had nine equipped] he told me at no time did they ever have more than six of the nine running; also that the gross receipts of his road would not pay for the plates of the batteries sufficient to run his road. If any one doubted his word the books were open at any time to any one who might choose to investigate. What he said was substantiated by the actual running of his road. They ran the storage battery car in Danvers for I think one or two summers, I don't know by what company, I have forgotten. They had so much trouble from breakdowns, stoppages, having to walk, that they applied to the city council to have poles and wires erected and have the trolley system in order not to be so entirely behind their neighbors. When I was east this summer I noticed that that road was equipped with the trolley system. How long the road in Washington and this other one runs will absolutely depend on the amount of money of the parties who are running it. As to its commercial success I am not an enthusiast. I would also say, however, and I think every street railway man will say the same, that we would welcome a practical storage battery. There is one other place that possibly has not been thought of in which to use the storage battery, and that is regulating the light taken from the street railway circuit, to get a constant light or in other words to do away with the fluctuation owing to the difference of load from a street railway line. I am now making some modest experiments to endeavor to determine that. When I get out of one difficulty I get into something that is worse. Whether I ever succeed in doing anything rather depends on the length of my life, I think.

MR. SEARLES:—The quotation of the weight I understand to be 60 pounds per cell and that was commented on in the paper as being too light for continuous use. The circular of the Washburn car puts the weight of their cell at 40 pounds. I would like to ask whether it was

possible under the arrangement of their invention to consider 40 pounds as a practical weight.

MR. UBERLACHER:—I think that the Washburn company called the weight of their 150 pound ampere cell 40 pounds and stated that they would use 180 of these cells to the car. This would raise the weight of the car 7200 pounds. The ordinary rule has been [I don't know how it would compare in capacity with the Washburn capacity] that the weight of battery per car ran two or two and one-half tons, considerably lighter than the Washburn estimate. I don't know what their idea is in increasing the weight of their battery. I have referred to 60 pounds as the weight of the Waddell iron and copper battery. In that battery the weight does not seem to injure the life of the cells: it is a different thing altogether from a lead battery. In the lead battery I don't think that any cell weighing less than 100 pounds per horse power hour has ever been able to stand the jar and the heavy discharges incurred in that service.

MR. ROBERTS:—I am not quite sure whether it was sufficiently explained to Mr. Searles. He has evidently confused the weight of the cells with the weight necessary to give one horse power hour.

CEDAR BLOCK PAVING.

BY THOS. APPLETON, MEMBER, WESTERN SOCIETY OF ENGINEERS.

[Read October 5, 1892.]

Cedar Block Paving has been used for a great many years, and doubtless will be used extensively for many years to come. It is comparatively noiseless: it affords a good foothold for horses; it is not dusty; it is not slippery, excepting when covered with mud or sleet, and when in good condition it affords a smooth surface for vehicles, and moreover it is cheap. Therein lies its chief advantage. Among the criticisms upon it, the chief objection comes from a sanitary point of view, in that the wooden blocks readily absorb filth and moisture and decay rapidly.

The common cedar block becomes too rotten for further service in from seven to nine years. The decayed wood absorbs and retains moisture which hastens the decay of the remainder of the wood. The presence of large quantities of slowly decaying vegetable matter saturated with the excrement of animals cannot be otherwise than a menace to health. If wooden pavements must be used, any process which will lessen the capacity for absorbing moisture and retard the decay of the block will be a great advantage.

There are many localities, small cities, suburban towns and the outlying districts of the large cities, where the streets are almost unpassable in the spring time, and some form of improved roadway is a prime necessity. The tax required to meet the cost of a first class pavement would in many such places amount to the confiscation of the abutting property. In such cases the cheapest pavement is the only one that can be used, and here cedar block paving is the favorite.

The ordinary method of construction is as follows:

The curb stone is set to the true grade, and the ground between the curbs is graded to the true cross-section of the street, as closely as can be done by the use of shovel and mattock. After this the surface should be well rolled by a heavy steam roller. This is not always done, but it should be. One not accustomed to using steam rollers for this purpose will be surprised at the numerous soft spots exposed by the heavy roller. It detects immediately all imperfectly filled pipe trenches. Additional earth is placed over these soft spots and rolled in until the surface remains level after the passage of the roller.

After the surface has thus been properly prepared, some three inches of coarse sand is spread over the entire surface. One by twelve boards are then laid across the street from curb to curb, usually eight feet apart, and carefully bedded in the sand to the true cross-section of the roadway. These cross-wise boards, commonly called stringers, furnish a guide for leveling the sand and support the ends of the planks which form the foundation for the cedar blocks.

After the stringers are in place and well tamped, a straight edge or scraper reaching from one stringer to another is drawn from one side of the street to the other, thus leveling the sand flush with the top of the stringers. If the sand is damp it should be compacted by ramming. It would be well to have the scraper raised so as to leave the sand a little high above the stringers, in order to be sure that the foundation boards have a perfect support throughout their entire surface, which is the chief object of using sand in this place. Sand can easily be fitted to the true surface, while it would be almost impossible to grade ordinary clay as nicely. The sand also assists in draining away any water which percolates through the paving.

On the stringers and sand the foundation planks are laid close together lengthwise of the street: the ends abutting on the stringers. These planks are one or two inches in thickness and should be a pretty fair quality of lumber, well seasoned and dry. The purpose of this wood foundation is to support the blocks in their true position and prevent one block being forced down below its neighbor by the rolling wheel loads. As the foundation is supported continuously over every square inch of its surface by the sand, I believe one inch boards are plenty thick enough for the purpose. Inch boards have carried the

traffic until they decayed, and it is doubtful whether a rotten two inch plank will make any better support for paving than a rotten inch board. Sometimes the foundation boards have been dipped in hot coal tar before laying. If the board is well seasoned and perfectly dry, the coal tar immersion would increase the durability of the material, but if there is any sap or moisture in the lumber the coal tar would effectually seal it up and hasten dry rot inside.

In Franklin Street, East Saginaw, which was paved with cedar blocks resting on inch boards some ten or twelve years ago, the boards were dipped in hot tar. When the pavement was taken up last year these boards were sound enough to use for fencing, and many of them were sold on the spot for one-half the price of new lumber.

I believe better results would be obtained by subjecting the foundation plank to some preserving process, such as Burnettizing or creosoting. A one inch foundation preserved by the zinc process would cost considerably less than two inch plank not preserved, and I believe would last much longer.

Paving blocks are sawed from peeled cedar fence posts and run from four to eight inches in diameter. Six inches is a standard length, but some cities use blocks seven or eight inches long. Unless the travel is very heavy, a six inch block will perish by decay before it is worn short enough to crumble to pieces. When the traffic seems to warrant a block eight inches long, some different material for surface should be used instead of cedar. Brick, stone blocks or asphalt, would be appropriate for such cases.

The cedar blocks are placed on end close together upon the plank foundation, and are packed in such a way that the spaces between adjoining blocks are three sided rather than with four or more sides. The closest packing of blocks gives triangular spaces. Projecting knots or bunches on the side of the block should be cut off so that the blocks may stand close together.

Cedar blocks can be placed very rapidly by skilled men. As the blocks are of all sizes it is easy to select one of proper size to fill a given space properly. Occasionally it is necessary to split off a piece of a block in order to make it fit up closely against the adjoining blocks, and the somewhat paradoxical proposition is demonstrated that if a block is too small to fill a certain gap, it can be made big enough to fit by splitting off a piece of it. In paving against the curb or any other straight vertical surface, each alternate block should be split in halves, and the straight side placed against the curb.

After the blocks are in place the spaces between them are filled with gravel, rammed down by iron rods. Some specifications require that a paving cement, composed of coal tar and asphalt, shall be poured over the whole surface of the pavement, and run into the

spaces between the blocks. Others omit the paving cement. The cement serves a useful purpose in stopping up the spaces between the blocks, thus preventing water running down through the pavement, and it also sticks the blocks together so that they mutually support each other, and to a large extent, prevents the floating of the pavement when flooded with water. If this paving cement is used the blocks and gravel should be perfectly dry. The hot tar coming in contact with moisture, forms steam which blows the tar full of bubbles and destroys its cementing power. The entire surface of the pavement is then covered with about one inch of fine roofing gravel. When paving cement has been used this top dressing of gravel should be heated in order that it may bed itself into the tar.

I now come to what may be a novelty to some of the members, to-wit: A manufactured sapless cedar paving block.

In 1885-86, when I was City Engineer of East Saginaw, Mich., there was laid in that city a considerable quantity of sapless cedar paving. On most of the streets the travel was not heavy enough to wear out cedar paving before it would perish by decay. It was alleged that the sap portion of the cedar decayed much quicker than the heart wood, and hence, if the sap wood could be entirely removed the block would last much longer. It was also claimed that the soft sap wood soon gives way under travel and that the edges of the heart wood being thus deprived of support would broom up and turn over, leaving the block with a rounded top surface, and making a very rough pavement in the course of a few years. Hence the Board of Public Works decided to give the "Sapless Paving Block" a trial in hopes that these defects would be avoided. So far as I am aware, this was an untried experiment and required only the test of time to demonstrate the value of the sapless block.

Some of our suburban cities have recently asked for bids on "Sapless Cedar Block Paving" and this revived my interest in the matter and led me to make some inquiries. I learn that since '86 no common cedar blocks have been used in the city of East Saginaw and that the sapless block stands well. I have here some samples, sapless blocks that were laid in 1885 and '86, and common blocks laid at about the same time. Common cedar block paving gets to be pretty bad in six or seven years, no matter how light the travel may have been. One would say from the appearance of the sapless blocks that the travel must have been very light. The blocks are nearly of their original length, but they are sound on ends and sides, there is but little brooming of the top edges and no rounding of the top surface. The wood is hard, solid and bright.

Take the common blocks of the same age. The sap wood on the sides is so soft that it can be picked off by the fingers. The top edges

are crushed down; the heart wood is broomed over so that the top surface of the block is rounded.

Here are two common cedar paving blocks which I picked up from the space between the city and county buildings in this city. I am told the paving was laid four years ago. The travel there is almost nothing, but the decay goes on just as rapidly as at any other point. The sap wood is so soft that one can pull it entirely off with the fingers. One of the blocks is a split block and it shows how much faster the sap wood decays than the heart wood. The heart side is comparatively hard and sound, but the sap side is soft and punky. No doubt the presence of this sap wood hastens the decay of the heart wood. It becomes soft and holds moisture: it acts like a poultice on the surface of the heart wood.

The surface of the sapless block is in much better condition than the heart of the common block, although the sapless block is the older of the two.

In manufacturing the sapless block, the cedar is first sawed into block lengths. It is not necessary to remove the bark; this comes off with the sap wood. The blocks are then taken to a press or punching machine. The bed of this machine has holes four, five, six, seven, eight, nine and ten inches in diameter. At the top of these holes circular collars or knives are secured standing up two or three inches above the bed plate. A block is placed on one of these knives and the platen descending forces the block down through the hole in the bed, while the sap wood and bark is shaved off above the bed. The intention is to take off all the sap and no more, so that the attendant places the block over the largest die that he thinks the heart wood will fill. In case he misjudges the size of the heart wood and the resulting block still has some sap wood upon it, the block can be punched again through the next smaller size die and the sap wood entirely removed. Generally, the defective blocks as they come from the punching press are taken to a second machine, which has one straight knife and other knives of various radii of curvature, and these knives shave off any remaining sap wood or split off any decayed wood that may be on one side of the block.

The block from the punching press has a very pretty appearance. Each block is a perfect cylinder with sides straight and true. No knots or bunches are left, so that they can be set close together in paving. Those that have passed through the second machine have equally straight sides, but their cross section is not always a true circle; it may be a segment of a circle with a straight side. But there are plenty of places for split blocks, and as long as the blocks are sound and free from sap, it is not essential that they should all be exactly cylindrical.

The common cedar block is made only from small sized trees, of such size as would be used for fence posts. The sapless block is made from any size of tree, large or small, solid or hollow hearted. Any piece that has four inches of good heart wood goes into paving blocks, but the wood is all heart wood and of good sound timber.

The average cedar block has from 25 to 35 per cent sap wood upon it. Sap $\frac{3}{4}$ of an inch thick on a 7-inch block would make 24 per cent., sap wood. On a 4-inch block the same thickness of sap would make 34 per cent. of the entire area of the block. On some blocks the sap will run more than $\frac{3}{4}$ of an inch in thickness, as can be seen from the samples before you. Throwing away 34 per cent., of the material adds to the cost of the paving. A pertinent inquiry is, what does this sapless cedar block cost? On the first piece of cedar block paving in East Saginaw, the extra cost for sapless blocks was 10 cents per square yard over the cost of common blocks. Recent figures for sapless block paving in some of our suburbs give a difference of 30 cents per square yard. I understand that this latter difference is largely due to the cost of railroad freight from the block manufactory in Michigan. If the blocks were manufactured in this city, just as the common blocks are, this difference of 30 cents per square yard would probably be reduced.

What is the best method of paving in the outskirts of the large cities and in smaller cities and suburban towns, where travel is light and the property cannot stand any heavy assessments? I would answer: first, build your sewer, lay your water main and gas main; then put in a sewer connection, a water service pipe and gas service pipe, for every lot, whether the lot is occupied or not, at least as far as the edge of the sidewalk. Do all this work the summer before the paving is laid so that the back filling of the trenches may get the benefit of the fall rains, winter frosts, spring thaws and rains, and thus become well settled. It is a serious injury to any pavement to have it taken up for pipe trenches besides incommoding the travel while the work is going on. Hence all such work should be anticipated as far as possible. If any filling is required do that at the same time in order to have it well settled. If the assessment must be light, make the paving narrow. A pavement 16 or 20 feet wide is vastly better than a mud road of any width. A stone curb is good but costly. A timber curb will answer very well in first instance. 4 × 12 hemlock is sometimes used for curbing. 5 × 16 pine would be better. I would roll the grade with a steam roller, put on 3 inches of sand and 1 inch zinc treated boards and 6 inch sapless blocks, using paving cement only in case the pavement is liable to be flooded with water.

If a better pavement can be afforded, use 6 or 8 inches of broken stone thoroughly rolled with a heavy steam roller and omit the board

foundation. In any case a 4 inch tile laid about 4 feet below the curb and connected with suitable out-falls will add greatly to the durability of the pavement. It reduces the effect of frost. In many kinds of soil the main sewer has the same effect as a tile drain, but if the soil is water-proof or the sewer very deep, the drain tile will still be needed. Where there is no sewer, the drain tile should by no means be omitted. Even where there is no paving a well planned system of drain tiling is a wonderful help to a bad road.

A few words about special assessments. A recent law of the State of Illinois provides for making public improvements such as sewers, paving, etc., and paying for the work on the five year special assessment plan. That is, the cost of the work is assessed on the property benefitted, and the owner pays in five annual installments. The idea is a good one. If the owner is called upon to pay the entire special tax for any improvement at once, the tax is oftentimes burdensome. But if the burden is spread over a term of five years it is not felt so severely. In making improvements under this law, some muncipalities are getting the cart before the horse. They get some contractor to do the work long before they provide any money to pay him for it. After the work is done the assessment is made up and by and by some money is collected. In the meantime, the Contractor is carrying a pocket-full of papers, which are neither cash nor convertible into cash at any bank. When a Contractor has to take his pay in such unnegotiable paper, he adds ten, twenty or thirty per cent. to his prices and thus one of the objects of the five year plan, the lightening of the burden upon the property owner, is defeated.

There should be some means provided of paying the Contractor in cash promptly when his work is done. The municipality might issue five year bonds based upon the special assessments and such bonds would be readily taken at par by banking institutions. With the proceeds of these bonds the Contractor would be paid as his work proceeded and the prices would be much lower than is now charged for public improvements paid for in warrants.

While a paved roadway is a benefit to the abutting property, the community at large also receives great benefits from the improvement, and should of right bear some portion of the cost of the work. A good way to divide this cost would be to pay for the cost of paving street intersections, that is, so much of the space as is included in the intersecting street lines, out of the general street fund, and assess the abutting property for paving only what lies in front the lots.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

BOSTON SOCIETY OF CIVIL ENGINEERS.

OCT. 19TH. 1892:—A regular meeting was held at Wesleyan Hall, Bromfield Street, Boston, at 7.35 o'clock P. M. President Henry Manley in the chair, 54 members and 18 visitors present.

The record of the last meeting was read and approved.

Messrs. Henry S. Adams, Charles R. Felton and Alfred Stebbins, Jr. were elected members of the Society.

The President made a verbal report for the Board of Government in relation to leasing Room 8, Wesleyan Building for the library and reading room of the Society and Wesleyan Hall for the meetings. The Board recommended that the room be leased and fitted up for the use of the Society. After a statement from the Treasurer of the financial condition of the Society, on the motion of Mr. Whitney, the recommendation was adopted and the Board of Government was authorized to execute a lease for the use of the room and the hall for one year.

On motion of Mr. Hodgdon, the sum of $100 was appropriated to meet the expenses of moving and of fitting up the room.

On motion of Mr. Spalding the thanks of the Society were extended to Lieut. F. H. Holmes and Capt. Theo. Falk, for courtesies shown the members on the occasion of the excursion on the 19th. inst.

Mr. George S. Rice read a very interesting paper on Rapid Transit for Boston and its suburbs. The discussion which followed was participated in by the President and Messrs. Stearns, Doane, Howland and Allen.

Adjourned. S. E. TINKHAM, Secretary.

WESTERN SOCIETY OF ENGINEERS.

296TH. MEETING, NOV. 2, 1892:—The 296th. meeting of the Society was held at the rooms of the Central Traffic Association, The Rookery, Wednesday evening, November 2nd., 1892 at 8 P. M. President Randolph in the chair and some 50 members present.

The reading of the minutes of the last meeting was dispensed with.

The Secretary reported for the Board of Directors, the application for membership of Mr. Ralph Modjeski and the resignation of Mr. W. D. Ewart.

The following letter had been received from the Secretary of the Engineers' Club of St. Louis, which the Board presented to the Society for consideration.

ST. LOUIS, OCT, 26, 1892.

Secretary Western Society of Engineers:

Dear Sir:

At the last meeting of our Club the following amendment to the By-Laws was adopted.

"SEC. 8. EXCHANGE OF MEMBERS:—Any member of any other Society in the Association of Engineering Societies, in good standing, may become a member of this Club, when duly elected as described in Sec. 7, without paying the initiation fee, and with a release from the annual dues for such period, not over one year, as he may show by certificate he has paid in advance in the Society from which he comes, provided such Society shall have conferred like privileges on members of this Club."

You will see from the above that this Section only becomes operative with clubs having a similar By-law and we would request that the matter be brought to the attention of your Society. Trusting that you will look favorably upon this matter we remain.

Yours Truly,

ENGINEERS' CLUB OF ST. LOUIS.

ARTHUR THACHER, Secretary.

The letter was ordered printed in the Proceedings to be more intelligently considered at the next meeting.

The question of a badge for the Society was again brought up by a motion of Mr. R. P. Brown, that a committee be appointed by the chair for a further consideration of a design for a badge. Seconded and carried. Committee since appointed: Messrs. G. A. M. Liljencrantz, R. P. Brown, R. E. Brownell.

The president then introduced Mr. Chas. F. White, member Engineers' Club of St. Louis, Consulting Engineer of the Citizens Committee for the prevention of Smoke who very clearly described many of the details connected with the important question of systematic Smoke Prevention.

The members present took a lively interest in the matter and plied Mr. White with numerous questions eliciting much useful and instructive information.

President Randolph for the Society, thanked Mr. White for his interesting remarks.

It was moved and seconded that a committee of three be appointed by the chair to make arrangements for the Annual Meeting.

Mr. D. W. Mead concluded the meeting by reading a paper on the question of Street Paving—a continuation of the discussion on Mr. Appleton's paper on "Cedar Block Paving."

Adjourned. JOHN W. WESTON, Secretary.

ASSOCIATION OF ENGINEERING SOCIETIES.

ORGANIZED 1881.

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A PRACTICAL TEST OF COMPOUND LOCOMOTIVES IN REGULAR SERVICE.

SECOND PAPER.

BY C. H. HUDSON, MEMBER, WESTERN SOCIETY OF ENGINEERS.

[Read December 7, 1892.]

Upon October 7th., 1891, there was presented to this Society a paper, giving "A Practical Test of Compound Locomotives in Regular Service," in which was set forth the results of eleven months experience upon the East Tennessee, Virginia & Georgia Railway, with a number of two-cylinder Schenectady compound locomotives, working against a number of simple engines of like age, build and design, and in similar service.

The belief was stated in that paper that short trials, however accurate, were of much less value than long ones,—and that the real every day work, and that for a time long enough to cover all the vicissitudes of weather, work, fuel, and even men, was, after all, the true test of the engines. The tests considered were believed to be of sufficient length to prove the qualities of the system of compounding used, showing, as they did, that the engines in passenger service, gave an economy of 25.56 per cent. over the sister engines in ten months' work. In like manner the consolidation compounds were shown to have saved 24.70 per cent. of fuel over the simple consolidations in eleven months of like service.

Another year has passed, during which the comparative tests have been continued, and it is of this that this second paper will treat.

The comparison of the ten months' work of the passenger engines

running between Knoxville and Bristol was shown in the former paper as follows:

	Miles run.	Car miles.	Lbs. coal used.	Lbs. coal pr. cr. mile.	Saving.	Per cent.
2 Simple Engines,	107,885	564,995	6,263,654	11.086	....	....
1 Comp'd Engine,	48,100	254,204	2,097,911	8.252	2.834	25.56

The comparative statement of the work done during the past year is as follows:

	Miles run.	Car miles.	Lbs. coal used.	Lbs. coal pr. cr. mile	Saving.	Per cent.
2 Simple Engines,	144,652	823,618	8,994,000	10.920	....	....
1 Comp'd Engine,	68,170	373,044	3,081,200	8.260	2.660	24.36

We found that the average weight of the cars hauled by the simple engines was slightly in excess of those hauled by the compound, and have corrected the car miles by adding enough to the simple engines to equalize this difference and make the car miles of the same value (as to weight) in both cases. The error was a small fraction of one per cent.

It is quite likely that the figures of last year should have been corrected on the same account, though which way or to what extent has not been ascertained; and as the item is very small it may be neglected.

The above figures indicate that the compound has been worked during the past year at almost exactly the same amount of coal per car mile as used during the former year, while there has been an improvement in the simple engines of 1.49 per cent.

If we now combine the statements of the two years we have the following:

	Miles run.	Car miles.	Lbs. coal used.	Lbs. coal pr. cr. mile.	Saving.	Per cent.
2 Simple Engines,	252,537	1,388,613	15,257,654	10.988	....	....
1 Comp'd Engine,	116,270	627,248	5,179,111	8.257	2.731	24.85.

or a saving in fuel in two years, every day work, of 24.85 percent., and that too over an engine which is believed to be above the average in economy of fuel.

It should be borne in mind that this coal reported is *all the coal* used by the engine during this year including that used for firing up, banking fires and what might have been left in the fire box after runs.

A little light upon the consumption of coal per car mile may not be amiss.

The table below will show the consumption of coal per car mile upon a number of roads in various parts of the country, varying, of course, in grades, quality of coal and character of engines. These figures are taken mostly from published monthly reports of the motive power departments, though some figures were taken from published annual reports of the officials of the roads. They are all official and presumably

correct. We are without data as to grades, but have in some cases the average number of cars handled upon freight trains. This may in some degree show the conditions relative to the road over which the engines considered are run, upon which the average train load is 19.8 cars.

COAL USED PER PASSENGER CAR MILE.
(From Published Reports.)

Name of Road.	Months.	Lbs. Coal per Pass. Car Mile.	Ave. No. Frt. Cars per Train.
C. C. C. & St. L.	5	17.04	20.8
H. & St. Jo.	5	15.89	—
Mo. Pacific.	7	17.80	—
N. O. & N. E.	4	21.10	—
N. Y. P. & O.	6	15.12	25.3
N. Y., L. E. & W.	8	19.26	20.3
Wabash.	4	13.95	18.1
K. C., St. Jo. & C. B.	5	13.17	—
L. & N.	5	12.86	16.1
Union Pacific.	3	16.33	—
C. N. E. & W.	1	21.22	15.4
Chesapeake & Ohio.	1	14.76	22.9
Norfolk & Western.	2 yrs.	15.00	20.5
E. T. V. & G.	3 "	12.14	19.8
Average		16.12	

Here we have an average of 16.12 pounds, or almost 50 per cent. more than was used during the two years trial by the simple engine and twice as much as used by the compound.

In the *Railroad & Engineering Journal* of December, 1891, we find a statement much of this same kind, tabulated from answers to inquiries from the editor of that paper, and used, tabulated, to show the relative value of English and American engines. The statements are official and cover a year's or more work, and are unquestionably correct. They were selected as the representatives of American coal consumption. From them we have made calculations of coal used per car mile, as shown in the following table. We find several roads in the list that are in the former table.

CONSUMPTION OF COAL PER PASSENGER CAR MILE.

Name of Road.	Pounds,
Chesapeake & Ohio	14.09
Chicago & Alton	13.90
Cincinnati Southern	12.79
C. C. C. & St. L.	14.05
Louisville & Nashville	11.84

Illinois Central	16.68
Michigan Central	13.22
N. Y. L. E. & W.	17.34
N. Y. P. & O.	13.72
Pennsylvania, East of Pittsburg	13.64
Pennsylvania, West of Pittsburg	11.04
Philadelphia & Erie	15.62
Average	13.99

Here we have an average of 13.99, or a little over two pounds less than in the former table. Combining the two we have an average of 15.06 pounds per car mile. This is 80 per cent. more than was consumed during our two years work by our compound, and 37 per cent. more than was used by our two simple engines with which the compound was compared.

Doubtless some of these roads use coal somewhat inferior to that used in these tests, but, on the other hand, much of the coal used is claimed to be second to none in America; consequently it may be, and probably is superior to that used upon the East Tennessee, Virginia & Georgia Railway. We have not before us, however, any data on that subject.

Just how the grades affected the matter we cannot determine, as our data is imperfect. Very many of the roads mentioned are of lower grades,—very few, if any, have higher grades, though quite a number have probably about the same. At any rate, there is not enough difference in the grades or quality of the coal, or both combined, to account for the difference in the consumption of coal.

It seems a safe conclusion that the simple engines, with which the compounds are compared, are very economical in fuel: hence, the deductions as to economy of compounds are of absolute value.

Various reports of engine tests show better figures than are given in this yearly statement, but it should be borne in mind that they usually do not include the fuel used in firing up or in banking fires, but simply show that actually put in the fire-box during the trip. Quite a number of tests were made in this way with East Tennessee engine 254, the result of one set being shown below:

	Feet.	Lbs.
4 Trips Knoxville to Bristol, 131 mi. up grades in excess,	70	6.95
4 Trips Bristol to Knoxville, " " down " " "	70	4.20
1 Round Trip Knoxv. to Chatta. 112 mi. & return grades,	60	5.35
Average of the whole 1,270 miles per car mile,		5.47

A two cylinder compound built by the Rhode Island Locomotive Works was tested on the N. Y. P. & B. road and made ten round trips from Providence to New London and return, a road of light grade, (1-2

of 1 per cent.) showing an average consumption per car mile of 6.28 lbs., being only the coal actually used on the road. The same engine made sixteen round trips from Boston to Springfield and return, showing an average consumption of coal per car mile of 6.10 lbs. Here were two and one-half miles of 60 ft. grade and nine miles of from 40 to 50 ft. grade, and the balance low grade.

It may be said that the above tests were against a new York, Providence & Boston engine on that road, and against a Boston & Albany engine on that, and the results showed a saving of fuel of about 23 per cent. by the compound engine.

A Dean two cylinder compound was recently tested upon the Old Colony Railroad. Six trips between Boston and Fall River, on the Steamboat train, 10.8 cars, 35 miles per hour; eleven trips on the Shore Line Express, 5. 45 cars, 40 miles per hour. This was on a low grade road and with the best of coal. The coal considered was the coal used on the road, the engine showing a consumption, 1st. 4.22 pounds, 2nd. 7.09 pounds, and a saving of about 30 per cent. over the simple engines.

On the face of it this engine would seem to be more economical than the Rhode Island, but the grades were lighter and it is hard to say just what the exact relations are. It seems, however, to add testimony as to the economy of the two cylinder compound.

Both these and the Rhode Island engine tests are, as a whole, in line with the figures of the two cylinder engines first mentioned, but are open to the same objection that all short tests are, and are of much less real value than the long every day work of the two years comparisons.

During the past year we had a short test between a two cylinder and a four cylinder engine, the latter having two 14 & 24 × 24 cylinders with 72 inch wheel and a 62 inch boiler, while the two cylinder compound had 19 & 27 × 24″ cylinders, with 68″ wheel and 58″ boiler, intended to be the equivalent of 19 × 24″, while the four cylinder was intended to be the equivalent of 20 × 24, and had a 4″ larger wheel. In this case the fires in both engines were prepared from coal other than that on tender, and *only coal was considered that was used upon the road.*

The test consisted of four trips Knoxville to Bristol for each engine, on train No. 2. Distance 131 miles, 70 ft. grades, some very long. Four trips from Bristol to Knoxville on train No. 1, westbound, same distance and grade, excess of ascent towards Bristol. One round trip Knoxville to Chattanooga (112 miles) and return, trains 1 and 2, grades 60 feet. The coal was accurately measured, as was the water. The four cylinder engine was run by the man in charge of it for its owners, with such aid as he requested from the Company. The East Tennes-

see engine was run by a man but recently put on it, and certainly he did no better than would a man thoroughly used to it.

The total run was 1,270 miles for each engine, on day-light runs, same time, and so far as could be controlled, under the same conditions.

The results tabulated are as follows:

	2 Cylinder Compound.	4 Cylinder Compound.	Excess.	Decrease.	Per Cent.
Miles run........	1,270	1,270	—	—	—
Car miles.........	10,333	10,716	383	—	3.7
Coal used, lbs.....	56,649	69,850	13,201	—	23.3
Water used, lbs....	487,589	539,848	52,259	—	10.7
Water evaporated per pound coal.	8.66	7.73	—	0.93	10.7
Pounds coal per engine mile.	44.50	54.85	10.35	—	23.3
Pounds coal per car mile.	5.47	6.52	1.05	—	19.2

The actual car miles of the four cylinder was 10,760, but the average weight of the cars was forty-one-hundredths of 1 per cent. less than of the cars drawn by the two cylinder compound, and in order to equalize this and make the unit equal I have deducted 44 car miles, this being the same correction made in the years's report.

Taking the two cylinder engine as a basis, the four cylinder used 19.2 per cent, more coal per car mile than did the two cylinder.

The four cylinder engine, as before stated, was the more powerful of the two and did a little over 5 per cent. more work in the whole run.

It is to be presumed that she was well handled and made to give as good results as possible.

Just before coming to the East Tennessee, the same engine had been tested upon the Norfolk & Western, making, as given in published reports, four round trips from Roanoke to Bristol (151 miles) and return, in passenger service, showing a consumption of 7.5 lbs. coal per car mile. This was upon the same trains as upon the East Tennessee and over the same character of road and with *Pocahontas coal* the *only coal used on the road*, and of excellent quality.

This showing of 7.5 lbs. was 13 per cent. more than the 6.52 lbs. shown by the same engine upon the East Tennessee.

Unfortunately, there was no simple engine run against this four cylinder upon this particular test upon the Norfolk & Western.

As before stated, the 1,270 miles consisted of:

4 trips Knoxville to Bristol (131 miles) with maximum grade of 70 ft.

The total rise made on run........................	3,320 ft.
Total fall......................................	2,510 "
Net rise.........................	810 "

4 trips Bristol to Knoxville (131 miles) where the figures were reversed and we have,

Total rise......................	2,510 ft.
Total fall......................................	3,320 "
Net fall..........	810 "

1 Round trip Knoxville to Chattanooga (112 miles) and return, maximum grade 60 ft.

The effect of the grades is indicated by the figures in the following table:

	Coal per Car mile.		Evaporation of Water per lb. Coal.	
	2 Cyl.	4 Cyl.	2 Cyl.	4 Cyl.
4 trips. Knoxville to Bristol.......	6.95	7.56	7.81	7.19
4 trips, Bristol to Knoxville.......	4.20	5.45	10.00	8.26
1 round trip, Knoxville to Chattanooga and return.	5.35	6.39	8.17	8.02
Average....................	5.47	6.52	8.66	7.73

This was in passenger service.

On the trip up the grades to Bristol the four cylinder used only 8.5 per cent. more of coal per car mile, while on the down trip she used about 30 per cent. more. On the trip Knoxville to Chattanooga she used 19 per cent. more, being almost exactly the average of all the trips.

The water evaporation per pound of coal was better upon the two cylinder than upon the four cylinder, notwithstanding the fact that the latter had a much larger boiler.

Just what a year's work would show is a matter of conjecture, though the indications from this test would be in favor of the two cylinder, from the standpoint of economy in fuel.

In the same line and confirming the last figures is the test, also taken from published reports, of the same 4 cylinder engine upon the C. B. & Q. between Chicago and Galesburg, which shows up as follows:

Car Miles.	Pounds Coal	Avg. Lbs. Pr. Car Mile.
11,880	84,455	7.53

This was the amount put into the firebox *on the road.*

This over 165 miles of road, 85 miles of which has but *28 ft. maximum grade*, and not many miles of it, and eighty miles of which has 39 ft. maximum grade. against 70 ft. long grades of the E. T. V. & G. The difference can be understood when we say that the resistance from gravity on the 70 ft. grade is 26 lbs per ton,
while for 39 " " it " 15 " " "
and upon 28 " not quite 11 " " " averaging only 50 per cent. of the high grade, the resistance due friction being the same in all grades.

It will be seen that the grades were very much in favor of the C. B. & Q. test.

We have not the exact weight of cars, but a rough examination seems to show that the average weight of the cars in the C. B. & Q. train was slightly greater than on the E. T. V. & G. but not anywhere near enough to make up for the difference in grade.

The speed in the C. B. & Q. case was considerably greater, perhaps 20 per cent., being 42 miles against 35 of the other. This would add to the resistance, but only about 40 per cent., if it increases as the square of the speed, which is questionable.

Taking all these items into account, viz:

Less resistance due lighter grades
Greater " " increased speed
" " " heavier car

we may conclude that the relations are not very dissimilar and we ought to expect about the same amount of coal burned in the one test as the other.

We find however, on the	C. B. & Q.	7.53 lbs.
"	N. & W.	7.50 "
"	E. T. V. & G.	6.52 "

showing that the amount burned on the East Tennessee was not excessive, notwithstanding the fact that it was 19 per cent. in excess of what the two cylinder compound burned, viz: 5.47 lbs.

Another point was tested in the 1,270 miles run, between the 2-cylinder and 4-cylinder engines, in the way of the use of cylinder oil and is shown in the following:

	2-Cylinder.	4-Cylinder.
Pints of cylinder oil used	10	40
Miles run to pint	127	32

Here we find that *on that run* of 1,270 miles the 4-cylinder engine used 40 pints of cylinder oil, or four times as much as the 2-cylinder engine.

The oil went first into the valve cylinder of the four cylinder engine, which was found to be very well lubricated; thence into the high

pressure cylinder, which was fairly lubricated: thence into the low pressure cylinder, which seemed to be poorly lubricated, notwithstanding the larger amount of oil used. The cylinders of the 2-cylinder engine were lubricated about as usual and satisfactorily.

This cylinder oil is a very small item, and yet in one year would amount to about, for the

2-Cylinder................................ ...	$ 41.00
4-Cylinder.......	164.00
Saving by the 2-Cylinder...	$ 123.00

An item certainly worth saving,

No special effort was made by either engineer at economy of oils, either cylinder or lubricating, the 2-Cylinder engine using about as usual and what its engineer thought about right, while the amount used by the 4-Cylinder was what its engineer thought best, and unquestionably it was about all needed.

No comparisons were made with lubricating oils, no correct account having been kept with the 4-Cylinder engine.

Regarding the compounds in freight service, the two consolidations described in last year's paper have been run during the past year between Knoxville and Chattanooga continually, but no simple engines of the same age and condition have been run continually against them. Such engines have been run much of the time upon other parts of the road under different conditions of grades, etc., so that no comparison can be well made.

The engines that were run over the same road with the compounds were just out of the shops after general overhauling and consequently in better shape than an engine a year or two old, as were the compounds, and no comparison would be fair.

The statistics for eleven month's service in former paper were as follows:

SIMPLE.

	Eng. Miles.	Car Miles.	Avg. Crs. Per Trn.	Lbs. coal consumed.	Lbs. pr. cr mile.
4 Engs., East End, 6 mos.	81,226	1,335,045	16.43	8,252,533	6.532
4 " West End, 5 "	61,318	1,190,786	19.41	5,977,917	5.029
Total...............	142,544	2,525,821	17.23	14,230,450	5.634

COMPOUND.

	Eng. Miles.	Car Miles.	Avg. Crs. Per Trn.	Lbs. coal consumed.	Lbs. pr. cr mile.
2 Engs., East End, 6 mos.	27,682	495,050	17.88	2,454,142	4.957
2 " West End, 5 "	31,550	712,291	22.57	2,667,505	3.746
Total.................	59,232	1,207,341	20.38	5,121,647	4.242
Saving ...					1,892
Or...					24.70 pr. ct.

It will be noticed here that the coal per car mile upon the West End, with lower grades, was in the case of the simple engines 23 per

cent. less than upon the East End, while with the compounds it was 24 per cent. less.

It will be noticed also that on the West End the simple engines used

per car mile	5.029 lbs.
while the compounds used	3.746 "
Saving	1.283 "
Or	23.52 per cent.

While we have no simple engine service this year with which satisfactory comparisons can be made, we can compare the work of this year of the compounds with last, which comparisons seem to confirm last years figures so far as the compounds are concerned.

1892	Eng. Miles.	Car Miles.	Ave. Crs. pr. Trn.	Lbs. coal consumed.	Lbs. pr. car mile.
2 engines 12 months,	68,507	1,820,513	26,60	6,818,200	3,745

Here we have almost exactly the same consumption of coal per car mile for the year as was shown during the previous year, it

being	3. 745	1892
against	3. 746	1891.

Considering that the engines were a year older, and necessarily the machinery is looser in every way, it would seem that they were doing remarkably well to keep even with the previous year in their work.

That we may see the relation of this coal consumption to the general rates over this country, I give below a list of figures compiled, as

Name of Road.	Months.	Lbs. Coal per Car mile.	Average Load.
Alabama Great Southern	4	6.34	15.1
Alabama & Vicksburg	4	6.47	16.7
Cincinnati Southern	4	7.46	14.0
C., C., C. & St. Louis	5	5.97	20.8
Hannibal & St. Jo	5	6.50	—
Missouri Pacific	7	6.40	—
N. O. & N. E	4	6.19	—
N. Y. P. & O	6	7.52	25.3
N. Y., L. E. & W	8	6.32	20.3
V., S. & P	3	6.63	—
Wabash	4	6.05	18.1
K. C., St. Jo. & C. B	5	5.35	—
L. & N	5	6.87	16.1
Union Pacific	3	8.90	—
C., N. E. & W	1	7.07	15.4
C. & O	1	5.76	22.9
N. & W	2 yrs.	7.50	20.5
E. T. V & G	3 "	5.56	19.8
Average		6.60	

in the case of the passenger engines, from published official reports of motive power departments and general officers.

As in the case with the passenger figures, we will introduce a statement prepared from figures from the December, 1891, *Engineering Journal*, showing the consumption of coal per freight car mile on the leading American roads, as before stated, selected to compare with English consumption.

Roads.	Lbs. per Car mile.
Chesapeake & Ohio	6.74
Chicago & Alton	4.73
Cincinnati Southern	4.30
C. C. C. & St. L.	4.99
Illinois Central	7.06
Louisville & Nashville	7.11
Michigan Central	4.00
N. Y. L. E. & W.	5.61
N. Y. P. & O.	6.17
Pennsylvania (East of Pittsburg)	5.58
Pennsylvania (West of Pittsburg)	4.20
Philadelphia & Erie	4.71
Average	5.23

It will be noticed that in a number of these cases the figures are much below those of the first statement, the average of the whole being 1.37 lbs. less.

Taking an average of the two we have 6.07 lbs. per freight car mile, which may probably be taken as a fair average figure for American roads. This however, is about 60 per cent. more than the two-cylinder compound used on an average for two years' work upon the East Tennessee, and upon grades it is believed equal on an average to those of the roads included in the above statements.

We believe we are justified in claiming for the freight compounds for the two years the same superiority so far as consumption of fuel is concerned, as was shown during the former year, and as was shown by the passenger engines for the two years.

The item of repairs is the one on which the *doubters* harp, claiming that the saving in coal, if it be cheap, is so small that it is more than made up by the increased repairs of the engines.

The statement for last year showed for the 10-wheeler in passenger service.

	Miles.	Cost.	Cost per mile in cents.
2 Simple 6 months	69,220	$1,213.12	1.75
1 Compound 6 months	29,864	527.51	1.77

For the present year it was:

2 Simple	144,652	$3,763.88	2.62
1 Compound	68,170	1,831.33	2.68

While we have an increase here, the relations are about the same

Combined we have:

2 Simple 1 1-2 years,	213,872	$4,977.00	2.33
1 Compound " "	98,034	2,358.84	2.40

Here seems to be a slightly increased cost for the compound, or about 3 per cent., which would amount to about 23 dollars per year, while the coal saved would amount to 850 tons, or say about $1,275, at $1.50 per ton, a sum so much more than the additional repairs, even if the excess was ten times $23, as to make the compounding valuable beyond question.

As to the freight engines, our last year's statistics were:

	Miles.	Cost.	Cost per mile in cents.
4 Simple Engines,	76,827	$1,312.66	1.70
2 Compound "	39,268	612.72	1.55

For the year just passed we have no engine exclusively on the same runs as the compounds. We, however, have taken eleven simple engines of the *same age* as the compounds that have been run in about the same character of service and during the year averaged about the same mileage, though not on the same part of the road. This for car mileage comparison would not do, but for engine mileage is certainly not objectionable.

The figures for the year are:

	Miles.	Cost.	Cost per mile in cents.
11 Simple Engines,	370,655	$8,651.62	2.33
2 Compound "	68,503	1,690.46	2.47

Now combining the two years, or one and one-half years, more properly, we have:

4 Simple Engines 1891,	76,827	1,312.66	1.70
11 " " 1892,	370,655	8,651.62	2.33
Total	447,482	$9,964.28	2.23
2 Comp'd Engines 1891,	39,268	$ 612.72	1.55
2 " " 1892,	68,503	1,690.46	2.47
Total	107,771	$2,303.18	2.14

Here we find that while for this year the repairs of the compounds were a trifle more per mile run, they were, for the year and a half considered, a trifle less.

It has been claimed that the large cylinder would wear upon the

bottom much more than upon the sides, caused perhaps by the greater weight of the piston.

An examination of the cylinders of two simple consolidations of the same age and having had about the same service as the compounds was made, and at the same time an examination of one consolidation compound and one 10-wheeled (passenger) compound.

Accurate measurements of inside diameter were made four inches from the front head and at points four inches apart the entire length of the cylinder, the measurements being both vertically and horizontally, and in both cylinders.

It was found that on the first engine examined (simple) the right hand cylinder had elongated vertically....................0.103 inches,
while the left hand had elongated horizontally..........0.024 "

Why this should be is now known. The vertical elongation of the right hand cylinder was the greatest found in the examinations.

In the second engine, (simple) the elongation was the same in both cylinders and vertical........ ....0.017 inches,

In the third engine (compound consolidation) the elongation was vertical, the right hand cylinder.........................0.021 inches,
and on the left hand vertical, but very small.... ....0.007 "
three of the measurements showing nothing.

For the fourth (passenger compound) the right hand cylinder showed a vertical elongation of.......... ....0.077 inches,
while the left showed...................................0.044 "

Comparing the simple with the compounds, the average elongations are:

	SIMPLE.	COMPOUND.
Right hand cylinder...	.0600 inches.	.0495 inches.
Left hand cylinder................	.0205 "	.0255 "

It will be noticed that the elongation in the right hand cylinder as a rule is the most. The average of the four engines is as follows:

Right hand......................	.0545 inches.
Left hand......................	.0230 "

Another singular fact was developed, viz: that the extra wear was apt to be quite as much at the top of the cylinder as at the bottom, regardless of kind of engine.

To provide against any wear of this kind, the piston rods have on later engines been lengthened and a bearing obtained at both ends of the cylinder, the front end of the rod running into a pocket prepared for the purpose.

The effect of this seems good and it perhaps would do as well applied to the simple engines.

A careful examination of the pins was made to ascertain what if any difference in wear was to be found there, either as between the en-

gines or sides of the engines, and no measurable difference was found; almost absolutely no wear was discoverable.

This examination into the wear of the cylinders is not extended enough to be of any special value, except as an indication that there is probably no material increase because of the increased size of cylinder.

We believe that our examinations into the performance of these engines confirm the impressions formed a year ago, and that we can do no better than to repeat with emphasis the concluding sentence of the former paper, viz:

"*It seems safe to conclude that the compound principle as developed in these engines is a valuable improvement upon the simple engines and that the increased economy in fuel is of sufficient magnitude to more than overcome any possible increased repairs.*"

DISCUSSION.

PROF. A. T. WOODS:—I did not come in with the intention of saying anything on this subject, but to hear what Mr. Hudson had to say. I think his paper simply bears out what has been found in almost all cases where a compound has been given a fair trial. Mr. Hudson's figures are given, as I understand, on a car mile basis, and while that will answer very well for long periods of time such as he gives and will give a general result, I do not think it quite fair in the cases he mentions for the short trials. It has been found in other tests, those for instance that were carried out on the Milwaukee & St. Paul last year, that if the results are figured on a car-mileage basis, or on the ton-mileage basis and then from the dynamometer records,—from the actual pull on the draw-bar,—there is a great difference. The weight of the car is simply very little indication of its resistance, as shown by the dynamometer. That may very possibly account for the great difference which he finds between the four cylinder and two cylinder engines which I believe, has not been found as a rule in other cases. I am not prepared to say myself from anything I have read or seen in experiments, that it is clearly demonstrated that one type of compound is superior to any other.

MR. A. C. HARDING:—To my mind, the question of comparative economy of locomotive engines is a question of exhaust nozzle. I cannot, off-hand, produce data in support of this position. I am fully satisfied that to the nozzle a large per cent. of the compound's economy is due.

I am a strong believer in multiple expansion, but from high pressuse experience I have had, I am satisfied that if you should take an ordinary locomotive and give it a free exhaust, and introduce induced draft, produced by a fan in the stack, operated by an independent en-

gine, you would secure for the simple locomotive as high economy as now claimed for the compound.

Full speed cards frequently show back pressure representing a loss of 150 I. H. P., 90 per cent. of this loss chargable to the contracted exhaust required to produce sufficient draft. A blast in the stack is the most wasteful known method of moving a column of air. A fan and a 10 H.P. simple engine will force or pull more air through grate bars and tubes than the sharpest locomotive exhaust.

I am satisfied that 10 per cent. or more, out of the 25 per cent. economy claimed for the compound over the simple, is due to the fact that you put on a large exhaust nozzle, or which amounts to the same thing, pass a less weight of steam per revolution through the same size nozzle.

CEDAR BLOCK PAVING.*

II.

DISCUSSION.

Mr. D. W. Mead: I have very little to say directly concerning cedar block paving, as it is a line of paving with which I am not particularly well acquainted. I can say, however, that I have noticed in most of the cedar block pavements, where I have tried to keep track of their wearing qualities from the time they were first put down till the signs of decay appear, that the pavement seems to go to pieces first from the decay of the sap wood. I noticed in the Rockford pavements, which have now been down I think but two years, in positions where there would be no perceptible wear, where there is practically no traffic, in close proximity to the curbing and in places where nothing but foot passengers passed over it, a ring of decayed wood (the sap wood) appear around each one of the blocks, and I think, as Mr. Appleton said, that it is undoubtedly the cause of the breaking up of the heart wood of the pavement. The center part of the paving block, the heart wood, loses the support of the surrounding blocks on account of the decay of the small rings of sap wood and the pavement goes to pieces.

There is one point, however, that appeared to me during the reading of Mr. Appleton's paper, in connection with the samples of blocks which were presented, the blocks from East Saginaw, and the blocks that were taken from the Chicago pavements—it occurred to me that

*By Thos. Appleton, Member Western Society of Engineers. (See November issue, page 556.)

perhaps a portion of the difference in the apparent wear of the blocks was due, not so much to the sapless block, as to the soil on which the blocks were laid. I am not at all familiar with East Saginaw, or with the formation of the soil at that point, but we all know what the soil is in and about Chicago and my own impression is that any clay subsoil where water will accumulate more or less, will give rise to rot in the block and cause more rapid decay than in a sandy soil. I have kept watch of this point in Rockford to some extent, but the pavements there are too new to see any marked difference as yet. On the east side of the river, at Rockford, the soil is very sandy, I believe, about 100 feet of sand and gravel lies below the surface, while on the west side the rocks outcrop in places, and through the main street the clay over-lies the rocks and the drainage is much more imperfect than on the east side. I believe that there will be a marked difference in the wearing qualities of the pavement for that reason.

There is another point of which I would like to speak in connection with cedar blocks or other classes of pavement. A pavement is an engineering structure, and being an engineering structure, it seems to me that it demands just as much study and just as much thought in its design as a larger engineering work. A bridge engineer would hardly think of recommending a cantilevér bridge without examining the locality, because another style of bridge might be cheaper, and better adapted for the place. In any other engineering work, you would hardly decide what the work would be without examining what the locality requires: but we find with pavements, the usual method is to write to some other large cities and find what they have done, and without any regard to local resources, adopt those specifications, sometimes containing clauses which are simply absurd for the particular locality in which they are to be used: and these specifications are often adopted without any regard to the particular needs of the town where the pavement is to be laid. I know of a city, not 100 miles from Chicago, that had macadamized streets on which there was at least 12 inches of good sound macadam, when the streets were paved, the macadam was carted from the street and hemlock plank imported into the town at considerable expense and cedar block laid on the hemlock foundation. In that place, even if it had been necessary to obtain new broken stone, the work with the stone foundation could have been done much cheaper, and have given much better results both as to maintenance and ultimate life of the pavement.

Another example,—not in the line of cedar blocks, but of brick pavements. Brick pavement was first introduced into this state at Bloomington, where there is no local stone and stone must be imported at great expense; brick is the cheapest thing they could have for the foundation, therefore they spread a little sand or cinders on their sub-

grade and place a layer of brick flatwise and put another course of sand and another of brick from the Bloomington brick yards. This plan has been widely adopted without a thought of what could be done in different localities; it was adopted in places where there was any amount of stone and needless expense has been involved in the construction of pavement. Sometimes paving bricks are imported at large expense, costing $12 and $14 a thousand and used over 8 or 10 inches of broken stone as a foundation. I have known of brick being put in as the foundation, that is, the second course of brick laid flatwise, where that work costs 40 cents a square yard, and where it was entirely needless. It was simply so much money thrown away. At three places in this neighborhood, Clinton, Iowa, Davenport, Iowa, and Rockford, single course pavement has been tried. In Davenport 8 inches of broken stone has been used, at Rockford and Clinton 6 inches; along the Ohio River 6 inches gravel is used, in Peoria a large sized brick is used on six inch gravel; all of these making good substantial foundations for medium traffic, but the point that I wish to make as strong as possible, is that the local resources of every locality should be canvassed before the style of a pavement is decided on, and before the construction of the pavement is decided on, both as to the quality and character of the material from which the surface is to be made, and as to the character of the foundation, for I believe that this is the only way to get the greatest economy, and I speak of economy not entirely in a financial way, but in the taking into consideration all the demands which are intended to be fulfilled by a pavement.

Now one word more in regard to the matter of special assessment, which was also touched on in this paper. The company which I represent is doing municipal work through this and adjoining states, and we had considered to do with the paper issued in this state and of the states adjoining. The members of our State legislature in their wisdom have seen fit to try to secure to the inhabitants of towns and villages all the privileges possible in the payment of assessments for this class of improvements, and the provisions have been so extensive that they have reacted and perhaps worked unnecessary hardship on those who have to pay for the improvements. The paper which is issued, either for payment in one year, or for payment in five annual installments, is payable at any time the property owner so desires. The five year paper, for instance, may be paid when the assessment is levied; it may be paid in five annual installments, or it may be paid at any one of the dates when a certain amount is due, or at any time between these dates. The result of this is that the paper is very undesirable for capitalists to handle, because if they invest in this scrip, unless they keep close and constant watch they are apt to find certain portions of it paid in and their money not paying interest. The result is that it is

almost impossible to sell the paper outside of the city or town wherein it is issued. That of course limits the market very much, and consequently the price of the paper is much lower than it should be. The paper is sold in places as high as 98. I know of a town which might be regarded as a suburb of Chicago where the best price the contractors could get for paper was 90. Of course the contractor must take this into consideration, and although he is not very apt. with the present competition, to add 20 or 30 per cent. as was suggested, nevertheless a certain amount must be added. I do not believe it would be possible under the present laws, for a city to issue bonds with this special assessment scrip as a basis. I think a law allowing bonds to be issued would be very desirable. Such a law is in force in Iowa, and we have handled considerable of the Iowa paper and we have taken it at par, regarding it as equivalent to cash. The cities of Iowa issue city bonds for any assessment, for which the city is liable, and special improvement bonds which are issued by the city and are payable from the monies, assessed against the property in the district when collected. The paper finds ready sale and is about as good as cash. The only point in regard to that class of paper is the doubt which some parties hold as to whether cities who issue these bonds are exceeding the limit of the indebtedness. Many cities in Iowa, if all the bonds that are issued for public improvements were counted against them, would be far in excess of their limit. However, a great many of the best municipal attorneys hold that the issuing of these bonds, inasmuch as a method of payment is provided, is not within the meaning of the statute of limitations. Although the bonds are perfectly secure, yet some of the banking firms will not handle them until it has gone to the Supreme court and it has not yet been thus far. If a law to the same effect was passed in Illinois, and it was also provided that these installments could be paid only at the date of maturity, the paper would have much better market value and the citizens of our town would get the benefit of that provision.

MR. O. B. GREEN:—Mr. Williams, from your long experience, would you think taking the sap off cedar blocks would be justified here in this city.

MR. BENEZETTE WILLIAMS:—I have had no experience that would warrant me in expressing an opinion. There is one thing, though, that the paper and discussion has suggested to me, regarding which I would like to hear some expression from those who have given special attention to it. Taking the outlying districts and suburban places, what would be the relative cost of a pavement of this character as compared with a brick pavement of the best kind. Mr. Mead and Mr. Appleton ought to be able to give us some information, I think.

MR. MEAD:—I hardly think that I could give information on that

subject, as the varieties of brick pavement and the varieties of cedar block are almost boundless in number, and as I have tried to say before, every town should figure out a question of that kind itself and take into consideration the resources of that particular town, which would modify largely the cost of either brick or cedar block.

Some time ago I had to look up the question of brick for some of the Minnesota cities, and the rate named made a brick pavement entirely out of the question. The rate from the brick kilns to the Minnesota towns cost as much as the brick themselves, and raised the price so high that it was out of the question to put the brick in. Of course you have to select your circumstances and your locallty before you could solve the question of that kind, then it would be a matter of equating those points.

MR. WILLIAMS:—The first object would be to know what the life of a brick pavement would be, and the life of a wooden pavement under like conditions, where there is not much heavy teaming.

MR. APPLETON:—In regard to the life of cedar block pavement, I know that in East Saginaw cedar block paving has been down nine years: it was pretty bad at that time, that is, we called it bad in East Saginaw—nine years old, but it was not near as bad as the wooden paving blocks right in the heart of this city, but it was bad for East Saginaw. Washington Street in that city was paved some nine years ago; Franklin Street was paved 11 years: in these cases the trouble was rot. The life of the pavement dependent on the decay of the block you may call from nine to ten years with common pavement. What the life of a sapless block would be I cannot say. Here is a sapless block in use for six years and it looks as though it was good for another six years at least. It has not suffered,—the block is hard. I do not know whether it would last 36 years or not. Saginaw pavements rot out.

Under a heavy traffic it would wear out, whether sap-wood or not. Take it in Chicago, the travel would wear the block off, so that decay would not cut much of a figure. What I advocated in my paper was this kind of block for light traffic streets where decay did cut a big figure, but in heavy traffic streets the block would be worn short and go to pieces.

MR. GREEN:—Then the implication is that you would not favor it for heavy traffic.

MR. APPLETON:—There are degrees; I do not know what you would call heavy. I said in my paper that where the traffic was heavy enough to seem to warrant 8 inck blocks, I would not use cedar blocks at all, I would use asphalt or stone or brick.

MR. WILLIAMS:—Does any one know the life of brick pavement? That would be interesting to learn.

Mr. Mead:—I do not want to take up too much time, but in regard to the life of brick paving I would say that I know of brick pavement in Bloomington that has been in about 18 years. Brick at that place are made out of common drift clays, and are softer and more porous than the regular paving brick, and although they are worn much in places, the pavement is a good pavement yet, and needs very little repair. I have seen brick at Wheeling, Virginia, that have been in use for 9 and 12 and in one case I think 16 years. I saw them at that place about two years ago; they were all in good condition, none of them needing repairs of any kind.

Brick pavement at Bloomington is laid on the principal streets. The pavements that I saw at Wheeling are on what you might call secondary streets; they are streets with more or less business, not residence streets, but not heavy traffic.

Mr. Green:—You would call Bloomington rural wear?

Mr. Mead:—Yes, I suppose in comparison with the heart of Chicago, but the wear that the pavements get in Bloomington would be much greater than the wear on the residence streets in Chicago, I should judge. The brick in Clinton, Davenport, and almost any number of cities that you might name in western Illinois and eastern Iowa, have been down from times varying from one to seven years. The brick at Galesburg has been laid for seven years; these brick are a paving brick; they are made from the shale clays and they are dense, hard, impervious and will stand a great deal of wear without disintegration. The great trouble is in the proper selection of the brick. The pavements that have gone to pieces have gone on account of being made of soft brick and through the action of frost more than the action of traffic. The brick when properly laid is level and the traffic that passes over it will not hammer it as traffic hammers a granite pavement,—the brick being even and kept in that position, there is not the wear and constant jolt that there is on the granite, and the pavement does not get the chance to wear out as on an uneven pavement. Of course, if the brick begins to settle, then you will see the edges of the brick give way, but if the brick is kept in proper position, they will last a great many years without appreciable wear. At Clinton the brick get heavy traffic from the lumber mills,—the traffic is heavier there than you get on the suburban or resident streets of Chicago, although not equal to what you get in the heart of the city.

Mr. Appleton:—I would like to hear from Mr. Chanute as to what he would say in regard to my recommendation in regard to preserving the foundation.

Mr. Chanute:—I had hoped that the discussion would dwell upon the merits of this very interesting paper, rather than upon the incidental recommendation which Mr. Appleton has made for the preserva-

tion of the wood. The wood can be preserved effectually by creosote: that is the best but also the most expensive method. It can be preserved nearly as well at about one-third of the cost by the burnetizing or zinc process which he has recommended in his paper, and whether this should be used will depend upon the question of wear. Some years ago the surface of the bridge at St. Louis was laid with preserved wooden blocks as an experiment by Mr. Shaler Smith. These were made of gum wood, which, as you know, is perishable wood, rotting frequently within 8 months. Those blocks were prepared by the zinc process and laid on the bridge—they were five inches thick, and when I examined them seven years afterwards,—they were quite sound, although they had been watered twice a day with a watering cart; but as they had to bear a great deal of traffic, they were worn down to a thickness of 2½ inches, so that in renewing them the bridge trustees re-laid the pavement with untreated cypress. In that case the pavement wore out, not from decay, but purely from the traffic and it was not therefore worth while to spend any money to preserve it. In the case of the sub-plank, which has been proposed by Mr. Appleton, I should think that the process would do excellently well. His paper is, I think, a very interesting and very important one, as pointing out one probable cause of the defect and the disfavor into which cedar block pavement has fallen, and I hope that in preparing it for the press, Mr. Appleton will add a comparative table, showing the cost, say in Chicago, of the various kinds of pavement, so as to furnish engineers who may read it more complete data as to the economy to be expected from what appears to be a valuable improvement in cedar block pavements.

MR. GREEN:—I should like to get the average of the life of wood pavement here in Chicago. I fancy it is about ten years, say, nine, in good order, I mean as a good road: for instance, on north LaSalle Street where there is a good deal of travel. It was put down in '81,—at the end of nine years it was a very fair driving street, but it has perished fast since and it is getting pretty rough. The south entrance to Wells Street bridge, then a very busy street, stood ten years. Now if we can get pavements that will last as long as that, I do not see but what the wooden pavement is the pavement for Chicago. I cannot see why so intelligent a people as the English should lay the approach to London Bridge, the greatest thoroughfare in the world, with Florida pine.—and I think they are laying it in Paris, also,—unless they think it the best.

MR. CHANUTE:—The most luxurious pavements in Paris are laid of wood, but it is selected wood, cut with great care, entirely free from sap, and creosoted.

MR. GREEN:—We might put a little more money into them; make the road of 6 inches of concrete, call the blocks the carpet, and renew the carpet whenever it is ragged.

Mr. Chanute:—That has been tried in Missouri and it is unsatisfactory because the concrete has been broken into to so often to repair pipes.

Mr. Green:—It would damage a bridge if you undermined the foundation. I saw it broken in London one day and I spoke to the contractor about it: he said the tariff that they put on a man for breaking into that foundation is enough to break the man, and the result is that in London, you rarely see the pavement broken. That was the portion of Mr. Appleton's paper was evidently intended for the rural districts.

I would like to see a good wooden pavement around the courthouse, then we would not have to use tanbark so that our judges could hear the testimony against boodlers. I am free to confess that I am a wooden pavement man, first, last and all the time, and I came here to be braced up.

Mr. Robt. P. Brown:—Mr. Appleton speaks of using inch boards for foundation, I do not believe in one inch boards for foundation from experience in streets that I have torn up here, it gives way and the pavement wears out so much the quicker.

As to these old blocks, they were cull blocks and should never have been laid any where, but they were laid as being better than nothing, in that sidewalk which had always been a disgrace to the city. The traffic across it was confined to a gateway.

The paving had practically no fall and what water gets on it seeps through and stays in the mud under it.

So we do not know the condition of this block when it was laid nor the usage of it. These blocks were only taken up in order to place the foundation. I can show many better blocks than these from residence streets which have been down 13 years.

Cedar paving is made to last in Chicago twelve or thirteen years on residence streets which have a through traffic, I have not torn up any on short side streets. It cost in those days about $1.20 per yd.

On business streets with car tracks it will last about six years, but we get very heavy teaming on our streets.

We are now getting our paving for an average of about 95c. per yard.

The reason we do not have better streets in Chicago is because the people are assessed each time the full cost of the work, naturally the majority refuse to pay for paving until the street is a perfect disgrace.

Cedar block laid under our plan should not be laid down town. We should do it better then it would last longer. Around the Grand Central Depot on Harrison street there was put 8 inches of macadam, in this was bedded 2 × 8 stringers: on this was laid 3″ *surfaced* pine plank;

on this the blocks $2 \times 5 \times 5$ deep, every fourth row nailed. This pavement will last but it cost $2.80 per yd.

I will say that our cedar block paving in Chicago is not done good enough for the traffic and the value of the property but I think it plenty good enough for country towns where the paving will rot out before it wears out. It will not rot out in ten years and when property is held by the 100 foot frontage when one pays 90c. a yard it is enough but here with property worth $300.00 a foot and a heavy traffic people should have a better paving or pave oftener.

I sometimes hear it said that Cedar block paving smells but I never heard it said except at the instigation of a contractor for other paving. There is no smell from the paving as it lies in the street and I have found none about the old blocks, but there is generally a taint of sewer and gas about any hole dug in a street whether the pavement is granite or cedar.

A Member:—In England it is better than here. There the contractor has to keep the pavement in repair for ten or twelve years, and if a break is discovered any where, it must be immediately repaired. In that way they claim the pavement lasts much longer than in Chicago. There is one point I would like to ask about—where you have a sandy soil, if you put down six inches of crushed stone, and I understand the policy is to cover the surface of stone so as to fill all the interstices with sand, how much sand do you put on before you lay your blocks on?

Mr. Appleton:—I would say that would depend on the care with which the grade was prepared. If you had a very nice surface on your road of crushed stone, you would not need much sand, but if it was uneven, you must put on sand enough so that you can get a good surface on the pavement.

Mr. Hilgard:—I know of specifications where they specified putting down $2\frac{1}{2}$ inches of sand. It looks to me as if, on a good sandy soil, that money spent in crushed stone is money thrown away. I would like to mention that it seems to me that certainly a discrimination should be made in paving various localities as to the heaviness of the traffic. I have seen pavings being laid down in Paris, with a concrete foundation, 25 centimeters thick—about equal to 12 inches, and it has stood traffic perfectly, but the blocks were selected of extra good quality of timber, without sap and were creosoted, but I think principally the solidity of the foundation gave the pavement such excellent wearing qualities. I am surprised to hear that around the City Hall here such cheap wood pavement should be used, as would be laid further out. I think it would seem warranted to put down very solid foundation in such places, as near the City Hall; then it goes without saying that in such places more money should be spent than in suburban districts.

MR. D. W. MEAD.

At the October meeting of the Society in the discussion of Mr. Appleton's valuable paper on Cedar Block Paving it was suggested that an estimate of the comparative values of various pavements for localities in and about Chicago would be of interest. In furtherance of this suggestion the following notes on the various kinds of pavement are offered.

There are several qualities which must be considered when discussing the kind of pavement for a street. The importance of these qualities vary largely in different localities, with the class of traffic, use of property fronting on the street, etc.

The rank or relative importance to be given to the different qualities must be determined for each particular case. Those qualities may be considered under the heads of:

1. First Cost.
2. Cost of Maintenance.
3. Facility of Repairs.
4. Durability under Traffic.
5. Freedom from Noise.
6. Freedom from Dust.
7. Freedom from Decay.
8. Freedom from Absorption.
9. Foot hold for Horses.
10. Ease of Traction.

Some of those qualities overlap but they are all more or less independent of each other.

1. First Cost and 2. Cost of Maintenance.

In the following table the writer has given an approximate estimate, for Chicago and its suburbs of the first cost of various pavements; the cost of their renewal when worn out; their approximate wear under light, medium and heavy traffic and also the approximate cost per year for a term of fifty years under these conditions.

In the last item, the first cost of the pavement, the cost of renewals and the interest of 6% on these amounts for the term of years invested is taken into consideration.

This table is partially based on certain experiments made in St, Louis, Mo., and by Prof. I. O. Baker of the Illinois State University, as given in his pamphlet on Paving Brick, and is substantiated by the writer's own experience and observation. The writer is more familiar with brick and cedar block paving and less so with granite, cobblestone and asphalt. He believes however that all estimates are conservative and within a safe margin of the actual cost and length of service, provided the work is properly done with first class material and properly repaired when taken up for laying or repairing pipes etc.

When a pavement is considered entirely unfit, or unnecessarily expensive for any class of traffic no estimate is given.

APPROXIMATE ESTIMATE OF COST OF VARIOUS PAVEMENTS, AND RELATIVE COST FOR TERM OF YEARS IN CHICAGO AND SUBURBS.

Class of Pavement and Kind of Foundation.	Cost per Sq. Yd.	Cost of Renewal.	Years of Wear under different Classes of Traffic.			Cost per year for term of Fifty Years under Different Classes of Traffic.		
			Light.	Medium.	Heavy.	Light.	Medium.	Heavy.
Cedar on two inch Plank.	$1.00	$0.90	10	7	—	$0.24	$0.35	$ —
Cedar on 6″ Rubble.	1.25	0.80	12	8	—	0.22	0.30	—
Cedar on 9″ Rubble.	1.40	0.80	—	9	4	—	0.30½	0.56
Cedar on 6″ Concrete.	1.40	0.80	12	9	—	0.22½	0.30½	—
Cedar on 9″ Concrete.	1.65	0.80	—	10	5	—	0.29	0.49
1 Course Brick on 6″ Rubble.	1.45	1.15	30	15	—	0.17	0.27	—
1 Course Brick on 9″ Rubble.	1.60	1.15	35	20	12	0.16	0.22½	0.30½
2 Courses Brick on 6″ Rubble.	1.95	1.15	35	20	12	0.17	0.23	0.31
1 Course Brick on 6″ Concrete.	1.60	1.15	35	20	10	0.16	0.22½	0.36
1 Course Brick on 9″ Concrete.	1.85	1.15	—	25	15	—	0.20½	0.29
Sheet Asphalt on 6″ Concrete.	3.00	2.00	15	8	—	0.50	0.75	—
Granite on Concrete.	3.50	2.00	50	30	15	0.28	0.37	0.54
Granite on 6″ Rubble.	3.15	2.00	50	25	12	0.27	0.35	0.56
Cobble Stone on 6″ Gravel.	0.90	0.70	—	15	8		0.16½	0.25
Macadam Granite dressing.	1.35	0.75	10	6	—	0.26	0.37½	—

3. Facility of repairs—is a matter of considerable importance to all cities: for the pavements are continually being torn up for laying and repairing the various pipe conduits etc., which are laid beneath their surface. Any pavement is injured by repeated and careless disturbance and frequently this is the principal cause that hastens their destruction.

Cedar pavements on plank foundations are seriously injured when trenches are cut through them. For their homogeneous bed on which depends their even surface and the equilization of pressure on their foundations is practically destroyed. The plank being cut off in sections as long as the width of the trench, when replaced, has long unbroken joints which are lines of weakness. Along these lines the pavement will settle and become uneven which produces rapid wear. It is true some cities require a whole section of pavement to be taken up when it is necessary to disturb it at all, thus avoiding the cutting of the plank foundation. This is very rare however, for in most cases the foundation plank are cut as above described. Brick, granite or cedar pavements on fragmentary foundations (that is, foundations of broken stone, sand or gravel) are much more easily repaired. In these cases homogeneity exists in the foundation by contact under compression and not by a continuity in the foundation material itself. Consequently a disturbance is not a permanent destruction to its homogeneity as in the case of the plank foundation. For in these cases by proper ramming the foundation can be made, almost or quite as if undisturbed and no marked lines of weakness result.

With concrete foundations lines of weakness are avoided when re-repairs are made by the union of new and old material in one homogeneous mass by the cement.

Brick being uniform in size are more easily replaced than granite and at a consequent less expense.

Asphalt pavements necessitate a somewhat expensive plant and expert help for its proper repairs which places this pavement at a disadvantage.

4. Durability under traffic—results from the resistance of the material to:

A. Crushing by the wheel load.

B. Abrasion by shoes of horses and friction of wheels.

C. Impact due to passage of loads over a rough surface.

A. Crushing—Granite will crush under load of from 13,000 to 22,000 lbs per sq. inch.

Paving Brick	10,000 to 18,000 lbs. per sq. inch.
Cedar	5,000 to 6,000 " " " "
Asphalt Concrete.	(?)

From this it will be seen that although the compressive strength

of Granite is on an average greater than that of Paving Brick yet the brick is sufficiently strong to afford a large factor of safety over the maximum load to which it will be subjected as a pavement.

Cedar and asphalt on the other hand have a much less compressive strength and will be rapidly injured and destroyed under the heaviest traffic.

B. Abrasive (by rattler test 1½ hours duration.)

Granite lost from ½ to 3½ per cent. (I. O. Baker.)

Paving brick 2½ to 5 " " (I. O. Baker.)

Cedar probably less than either (no tests.)

Asphaltum Concrete almost destroyed (St. Louis test.)

From this it will be seen that granite again outranks brick and it is probable that cedar if tested in the same manner would show a smaller loss than either.

Asphaltum concrete although almost destroyed in the St. Louis test is yet sufficiently tough to withstand (when homogeneous and continuous) the impact and abrasion of the horses shoes.

The rattler test for abrasion furnishes, however, hardly a fair comparison for materials having such different physical qualities as Granite or Brick and Cedar or Asphaltum.

C. Impact is most important in rough pavement.

A loaded wheel rising on an irregularity in the surface falls as it passes over it producing an effect in proportion to the weight on the wheel and the height of the fall.

This is the principal cause of wear in granite and cobble stone pavements and although granite exceeds brick in crushing and abrasive strength its roughness makes it average little if any better than brick in durability.

The smoothness of asphalt gives it considerable durability under traffic in spite of its inferior crushing and abrasive strength. But when once broken unless promptly repaired it will rapidly go to pieces under the impact caused by the surface irregularity.

Any depression or irregularity in a paved surface of any kind will produce a local failure through this cause, if not promptly remedied.

5. Freedom from noise.

Freedom from noise is of more importance than is commonly conceded. There is no doubt but that the continued noise of traffic gives rise to certain nervous diseases and it is certainly often a great disadvantage. So much so that it is frequently necessary in cases of sickness to spread bark, sawdust or straw over the pavements. And I believe the courts of this city are sometimes obliged to have tan bark spread over the neighboring pavements in order to hear testimony and transact business.

The noise of a pavement increases with its roughness, and to a limit-

ed extent with its hardness although this last item is comparatively insignificant.

Cedar when smoothly laid is the least noisy pavement except macadam, asphalt smooth but harder causes a noise from the horses shoes but otherwise is a quiet pavement.

The same may be said of brick which is only slightly more noisy than cedar and asphalt.

As for granite the rattle and roar of Chicago's streets is familiar to all, there is only one pavement more noisy and that is cobble stone.

6. Freedom from dust.

The dust of a pavement is due first to the disintegration of the paving material itself and second to the retention of street litter by irregularities in the pavement, which prevents its proper sweeping and cleaning.

Asphalt with its smooth continuous surface ranks first in this regard. Brick, almost as smooth and with close and well filled joints, ranks next.

Granite produces little dust from its own disintegration but its rough surface gives lodgement to dust from other sources.

The same is true of cobble stone to even a greater extent. Cedar in its wear gives off a light and very penetrating dust.

7. Freedom from decay.

Brick is made of the most lasting material, its elements have reached their most stable form. Granite, although it may be disintegrated in time, is eternal as far as atmospheric changes are concerned when compared with the life of the pavement as limited by other qualifications.

Asphalt will rot out unless kept clean; this usually occurs in the gutters and is not accompanied as far as the writer knows by unsanitary conditions.

Cedar like all wood is liable to decay; this element is an important one in the life of a cedar pavement and under light traffic is the most effective in its destruction. Its decay giving rise to noxious gases produce unsanitary conditions which are at least undesirable and under some conditions may be dangerous.

It may be here mentioned that after the epidemic of yellow fever in Memphis, Tenn., in 1876, one of the recommendations of the National Board of Health for the sanitary improvement of the city was that all wood paving should be taken up and carted out of the city. And on this recommendation several miles of wood pavement were so removed.

8. Freedom from absorption.—The surface of a pavement should be impervious to liquid filth, so that the subsoil may be pure and the pave-

ment itself in good sanitary condition. In this regard asphalt ranks first as it is practically impervious and it is a continuous sheet. Paving brick absorbs only from 0 to 4 per cent. of their weight and become, within a few weeks after they are laid, as impervious to the seapage of water through their joints as asphalt. Granite is in itself impervious or practically so but its irregularities of surface are apt to retain liquid impurities long enough to allow of some absorption through its joints. Cedar will readily absorb liquid filth and exhale it again in dry weather and its shrinkage from dryness or cold often opens seams which allow liquids to reach its foundation.

9 Foot hold for horses—The rougher pavements have here the advantages. Small cobble stone, undoubtedly furnish the best foot hold for horses and small granite blocks may be ranked next.

The many joints in a brick pavement offer facilities in this regard without the roughness of cobble stone and granite.

10. Ease of traction—The following table derived mostly from the experiments of different authorities whose names are given therein, gives a comparative statement of this point.

RESISTANCE TO TRACTION OF DIFFERENT CLASSES OF ROAD SURFACES.

(Horse moving at a pace.)

Character of Surface.	Resistance in terms of Load.	Authority.
Sand	1—5	Bevan.
Common Gravel	1—15	Mac Neil.
Hard Rolled Gravel	1—30	Minard.
Cobble Stone	1—16	Morin.
Good Macadam	1—30 to 1—54	Morin.
Granite Block	1—20 to 1—60	Mac Neil.
Plank Roadway	1—40 to 1—67	Morin.
New Cedar Block	1—50 to 1—80	
Old Cedar Block	1—20 to 1—50	
Good Brick	1—80 to 1—120	
Good Asphalt	1—133	Gordon.
Iron Tramway	1—200	Gordon.

In the following table the writer has tabulated these qualities and classified the different paving materials according to his idea of their relative rank.

CLASSIFICATION OF DIFFERENT MATERIALS AS REGARDS VARIOUS QUALITIES.—FOR CHICAGO AND ITS SUBURBS.

(All Pavements in First Class Condition.)

Qualities.	RANK. 1	2	3	4	5	6
First Cost...........	Cobble-stone.	Cedar.	Macadam.	Brick.	Asphalt.	Granite.
Cost of Maintenance......	Brick.	Granite.	Cobble-stone.	Asphalt.	Cedar.	Macadam.
Facility of Repair.........	Macadam.	Brick.	Granite.	Cobble-stone.	Cedar.	Asphalt.
Durability under Traffic...	Brick.	Granite.	Cobble-stone.	Asphalt.	Cedar.	Macadam.
Freedom from Noise......	Macadam.	Cedar.	Asphalt.	Brick.	Granite.	Cobble-stone.
Freedom from Dust.......	Asphalt.	Brick.	Granite.	Cedar.	Cobble-stone.	Macadam.
Freedom from Decay......	Brick.	Granite.	Cobble-stone.	Macadam.	Asphalt.	Cedar.
Freedom from Absorbtion.	Asphalt.	Brick.	Granite.	Cobble-stone.	Macadam.	Cedar.
Foot-hold for Horses......	Cobble-stone.	Granite.	Macadam.	Brick.	Cedar.	Asphalt.
Ease of Traction..........	Asphalt.	Brick.	Cedar.	Macadam.	Granite.	Cobble-stone.

Of foundations—Plank or boards is (in Chicago) the cheapest and poorest of foundations, especially so in clay soil where the water cannot rapidly drain away.

For light traffic the fragmentary materials (rubble, gravel, sand, etc.) or sand with a layer of brick laid on their side, or six inches of concrete make good foundations, the selection depending on the local resources.

For medium traffic nine inches of stone or gravel or stone, with a layer of brick laid on their side, bedded in sand, or six inches of concrete will give good results.

For heavy traffic the stone or gravel should be at least a foot in thickness or the concrete at least nine inches.

All sub-foundations which are retentive of water should be properly and thoroughly drained.

In regard to use of wooden pavements in Europe, Messrs. Q. A. Gillman, F. V. Green and E. P. North, all noted experts on paving, in their report to the Mayor of Philadelphia in 1884 write, "We are aware that at the present time large amounts of wooden pavements are being laid in London and Paris. As laid in those cities upon a foundation of concrete of Portland cement and of blocks of seasoned wood especially treated with preserving compound—they undoubtedly make a more durable road covering than the wooden pavements which proved so signal a failure in this country several years ago. But according to information received very recently from the French Engineers, it is expected to renew the wood every four or six years, depending on the amount of travel. The first cost of the pavements now being laid in Paris is equivalent to about four dollars per yard, and the contract price for repairs and maintenance is forty-nine cents per yard per annum, the contract being made for eighteen years. This brings the total cost during eighteen years to twelve dollars and eighty-two cents, which is about three times the cost, during the same period, of the pavement which we recommend."

Those gentlemen recommended granite, sheet asphalt and asphalt blocks for different grades of streets. As brick was at that time almost unknown it was not mentioned in the report. But it is worthy of note that Philadelphia is now laying considerable brick paving.

Mr. Thos. Appleton.

The discussion of my paper on Cedar Block Paving has drifted away somewhat from the original subject and Brick Paving has become quite prominent in the debate. Mr. Mead submits an estimate of cost of various kinds of pavements, including first cost maintenance and renewals for a term of fifty years. He gives figures for Common Cedar Blocks with various kinds of foundations, Brick laid in several

different ways, Sheet Asphalt, Granite, Cobble stones, and MacAdam. There are several other kinds of stone which are extensively used for paving blocks but are not mentioned in his table. Medina Sandstone, Colorado Sandstone, and Sioux Falls Jasper, are used in this vicinity and are superior to Granite. Limestone, which is not a good stone for paving but has been used in many places, is also omitted from his table.

Estimates of cost are at best only comparative. Local conditions may make great differences in cost. In one case the paving materials may have to be hauled in wagons three or four miles, while in another case the work may be within a quarter of a mile of the yard, so that even in the same city the cost of the same kind of paving may vary through a wide range. The cost per year for a term of fifty years as given in Mr. Mead's table is based upon certain assumed terms of wear under different classes of traffic, and it is unnecessary to say that with different terms of wear very different results could be reached. With what he calls "Light Traffic" he gives a life of 10 to 12 years to Common Cedar Blocks, 30 to 35 years to Brick, 15 to Asphalt, 50 to Granite and 10 to McAdam. I think he is unjust to the Sheet Asphalt, good Asphalt ought to last as long as Brick under "Light Traffic." For "heavy traffic" he allows 4 or 5 years to Common Cedar Blocks, 10 to 15 years to Brick, 12 to 15 years to Granite and 8 years to Cobble Stones. The terms "Light," "Medium" and "Heavy" are indefinite degrees of density of traffic, what one man would call "heavy traffic" another might consider but "medium." In one part of his paper Mr. Mead says that brick pavements were comparatively unknown in 1884. Yet in his table he assumes that brick will last 30 to 35 years under light traffic and 10 to 15 years under heavy traffic. I doubt if experience with brick pavements justifies the assumptions. There is one great difficulty in making a good brick pavement, and that is the great variation in the relative hardness of the brick. In the process of manufacture it is absolutely impossible to burn the brick all alike, one brick gets a great deal more heat than its neighbor, and so must be much harder. This variation in hardness does not occur in stone blocks nor in sapless cedar blocks, but is sure to show up in any brick pavement. In every brick pavement that I have examined there is at least one soft brick in every ten bricks, (and sometimes the soft ones are much more numerous) that shows itself after a few months wear, and makes a gap or depression which rapidly increases the wear on the adjoining bricks, no matter how hard they may be. Hence brick pavements need careful watching and prompt repair in fully as great a degree as any pavement that has been mentioned. My experience is limited, but I have never seen but one piece of brick pavement subjected to what I would call "heavy traffic," and how long it stood I

cannot say. It was at the intersection of Dearborn and Washington Streets, if I am not mistaken, in this city. I saw it when it was new and thought I would keep watch of it, as it seemed to be quite an innovation in the way of paving. I did not reside in this city at the time so did not see the pavement very often. When I looked for that pavement some two years later it was not there. It had been taken up and the place where it used to be had been paved with stone. It is a bold man that will predict a life of ten or 15 years for a brick pavement under such traffic as it would get at that street intersection.

In his table of estimates of cost, Mr. Mead figures the first cost of Sheet Asphalt at $3.00 and cost of renewals at $2.00 per square yard. Now the contractors for Sheet Asphalt guarantee to keep the pavement in good repair for 5 years free of cost, and they carry out their guarantee. In some cities they agree to keep the pavement in repair for an indefinite period after the first five years, for 8 cts. per sq. yard per year, which would make the total cost of Sheet Asphalt for fifty years, including six per cent interest on the first cost of $3.00 per yard, $15.60, or 31 2-10 cents per square yard per year, instead of 50 cents or 75 cents as given in Mr. Mead's table. If we assume the life of a brick pavement on six inches of concrete to be 20 years, 10 years and 5 years, for light, medium and heavy traffic, respectively, using the same figures for first cost and cost of renewal given in Mr. Mead's table, we should have the average cost per year for a term of fifty years, 22 9-10c., 38 1-10c., and 56 7-10c., instead of 16, 22 1-2 and 36 cts., as given in his table. Common Cedar Blocks on boards with the same prices for original cost and cost of renewals which Mr. Mead uses, but extending the life of the pavement to 12 and 9 years for light and medium traffic respectively, would make the average cost per year for a term of fifty years 23 1-2 and 29 1-2 cents instead of 24 and 35 cents as in the table.

With Sapless Cedar Blocks costing $1.35 per square yard and a life of 20 years under light traffic and 12 years under medium traffic, the average cost for a term of fifty years would be 22 7-10 and 34 1-2 cents per square yard.

Mr. Mead lays considerable stress on the injury done to a pavement with a plank foundation caused by cutting through the planks a gap the width of a trench to be excavated. It will readily be conceded that such a method of taking up such a pavement would cause a serious injury. But the person in charge of the city pavements who would permit any party to chop holes in the foundation planks of a pavement should be promptly discharged. Cities that allow such "wood butchering" deserve to have their pavements fail. When the plank foundation of a pavement is taken up each entire plank should be removed, and replaced without cutting or breaking. Then the stabil-

ityof the pavement would depend entirely upon the quality of the back filling of the trench, and the brick or asphalt pavement would suffer fully as much, if not more, from imperfectly filled trenches, as the wooden pavement. Trenches should be filled with sand or fine gravel. it is impossible to get the backfilling thoroughly compact with Chicago clay. But some persons use greater care than others in this work. I have known a piece of pavement taken up and a six inch sewer pipe laid and the backfilling so carefully done that the foreman called for more earth to fill the trench after he had put back all that was taken out. No pavement yet invented will withstand the abuse which pavements on the business streets of this city are subjected to. On LaSalle and Jackson streets the paving is taken up so frequently that it would seem that the paving stones suffer more wear from the picks and bars of the workmen than they do from the wheels of wagons. There is scarcely a week but some portion of the paving of these streets is dug up.

Figures as to the comparative strength per square inch, or experiments upon the loss by abrasion in a rattler box are of little value when comparing stone or brick with cedar blocks or asphalt for paving purposes. Wood and sheet asphalt have so much elasticity that they recover immediately from the effects of excessive loads. Moreover the continuous smooth surface of sheet asphalt does not permit the hammering from wagon wheels which occurs on any pavement having joints in its surface. Experiments on a few samples of stone may give results upon which some dependence can be placed, but the great variation in the hardness of brick, caused by unequal burning, would necessitate the testing of a great many samples in order to deduce results which would be of value. and just as a chain is no stronger than its weakest link. so the hardness of the softest brick determines the value of a brick pavement, rather than the average result of the samples tested.

I take exception to the "Classification of different materials" laid down by Mr. Mead. Under the head of "Cost of Maintenance" he places them in the following order:—Brick, Granite, Cobble-stone, Asphalt, Cedar, Macadam. I think he has got the Macadam in the right place, but I would put Cedar, Asphalt and Granite ahead of Brick. In reference to "Facility of Repair" he places them as follows:—Macadam, Brick, Granite; Cobble-stone, Cedar, Asphalt. Cedar block paving can be laid much more rapidly than stone or brick, and I fail to see how brick can be restored any easier than granite or cobble-stone. As for "Durability under Traffic," as already intimated we have no experience that will warrant placing brick at the head of the list as he does. He is right again with Macadam, placing it at the tail end of the list, but asphalt belongs at the head, and I should place granite ahead

of brick. Under the head of "Foothold for Horses" he ranks the materials as follows:—Cobble-stone, Granite, Macadam, Brick, Cedar Block, Asphalt.

It is a common, but I believe erroneous notion, that the joints or seams between the blocks of a pavement are essential for a foothold for horses. I grant that with any hard stone which polishes under wear it is absolutely necessary that there should be a limit to the polished surface in order that the horse can stand up at all, but a horse is less liable to fall upon a macadam or asphalt pavement than upon a stone pavement, and the yielding surface of the cedar block pavement gives a better foothold than brick or stone. In my opinion, Sheet Asphalt should transferred to the other end of the list. It has such a perfect surface that a horse's hoof comes immediately into position for work, there is no rocking of the fetlock joint, no slipping down into a crevice, no sliding off from a rounded summit. Besides no such effort is required to start a heavy load as is necessary in starting on a stone or brick pavement. I should rank the materials under this classification as follows:—Sheet Asphalt, Macadam, Cedar Block, Brick, Granite, Cobble-stone.

I doubt the utility of tables giving the cost of pavement for so long a term as fifty years, There may be several better pavements invented than any we now know of within the next ten years. One generation is about as far ahead as we ought to look.

In the present state of the art, I believe that for Chicago and its immediate vicinity there are but two kinds of pavement to use: First, if the abutting property can stand it, Sheet Asphalt: Second, Sapless Cedar Blocks.

There are fashions, fads, and popular crazes; even Engineering is affected by these spasmodic eruptions. Brick paving is quite popular at the present time, but I do not consider that it has as yet demonstrated its superiority, and am willing that others shall do the experimenting with it.

ASSOCIATION OF ENGINEERING SOCIETIES.

PROCEEDINGS.

ENGINEERS' CLUB OF ST. LOUIS.

371st. Meeting, November 2, 1892. The Club met at 8 p. m. at the club rooms, in the Odd-Fellows' Building, with President Johnson in the chair, and 32 members and 8 visitors present.

The Secretary, Mr. Thacher, being absent, Prof. H. A. Wheeler was appointed secretary pro tem.

The minutes of the 370th. meeting were read and after slight corrections, were approved. The report of the 136th meeting of the executive committee was read.

The applications of Messrs. Edwin James Jolley and Simon Leopold Weil for membership were read, and on balloting, both were unanimously elected.

The paper of the evening was then read by Mr. B. H. Colby, on "The Recent Survey of St. Louis; its Methods and Results." Mr. Colby gave the geodetic basis on which the work was founded, and the means adopted for securing monuments and bench marks on roofs, grave yards and in the streets. He then specified the instruments used: A Gambe, a Fauth and two Buff & Berger transits, all reading to 10 seconds. The method of taking multiple readings of the angles was described on the repetition system. The area already triangulated, exceeding 27,000 acres, was described and the number of stations occupied, which averaged two stations to the square mile. The base line used was from the old Water Tower to the City Insane Asylum, which has a length of almost six miles. Mr. Colby recommended that the granite monument recently erected in Forest Park, near the weather station, be hereafter adopted for the city datum, in lieu of the old city directrix, which had been destroyed. He stated that the error of closure in the triangles averaged 3.7 seconds and the mean error per angle was 1.2 seconds. The general system of triangulation was to carry a series of, with as few intervening triangles as possible, triangles from the base line to the extreme limits of the city. The method of keeping notes and making computations was then described. He mentioned that pole targets, which were difficult to see on account of the smoke, and were tampered with by mischievous boys, were replaced by heliotropes or flash signals, a very simple and yet effective design being employed. The flash system gave much better closures of the triangles, as the average was 1.6 seconds with the poles, and 2.7 seconds with flash signals, or an average of both systems of 3.7. The heliotropes also permitted the Morse alphabet to be used in telegraphing from station to station. The method of carrying on precise levelling was then described, and the instruments employed were exhibited. 743 benches have been established, or 12 per square mile, mostly on the stone sills of the buildings, the location of which is printed every year in the annual report of the sewer commissioner. The average error has been $^{1}/_{100}$ foot per mile. If the error of closure

was greater than 0.0208 feet into the square root of the distance in miles, the work was re-run. He then gave a new theory, based on studies made by Mr. E. J. Jolley, of this club, of the constant error found in precise levelling, which he explained as being due to always holding the eye-end of the level tube in carrying it, and therefore causing a local expansion of the eye-end of the tube that diminished the longer the instrument was used at a station, and hence the error was always greatest on the back sight. He stated that the topographic work was carried on with true azimuths. He gave the results of some stadia observations made after 4 p. m., whi h showed that the refraction error is so great as to sometimes make stadia work unreliable before 9 a. m., or after 4 p. m.; an error of 0.2 feet due to refraction was observed in 200 metres. Prefers to keep the topographic notes in the form of a few brief descriptions rather than by sketches. The methods employed in plotting were explained and a special protractor and slide rule exhibited. Mr. Colby also spoke of the different methods of graduating stadia boards, and gave some results that showed a marked tendency to error by the point system. Gave the results of carrying a stadia line around the perimeter of St. Louis that covered a distance of 40.4 miles, and 306 stations with an average length of 211 metres between stations. The maximum error in azimuth was 12 minutes and 35 seconds at a distance of 34.9 miles, and the closing error was 8 minutes and 20 seconds. The error in altitude in closing, after running the 40.4 miles, without checking on any intermediate benches, was $^{64}/_{100}$ foot, with a maximum of 1.37 feet at the twenty-seventh mile. The cost of the triangulation, topography, levelling and office work, covering all expenses for 815 working days, amounted to about \$35,000 at a cost of \$1.15 per acre, or 14.5c. per lot. The work was carried on by four engineers, with assistants, but only one party was in the field at a time, the others being busy in the office.

Discussion on the paper was postponed for a future meeting.

The paper for the next meeting on the "Intermural Railway at the Columbian Exposition" by B. J. Arnold was then announced.

Club adjourned at 10:30. H. A. WHEELER, Secretary pro tem.

372ND. MEETING, NOVEMBER 16, 1892. The club met at 8 p. m., at the club rooms, with President Johnson in the chair, twenty-one members and two visitors present.

In the absence of the secretary, Prof. H. A. Wheeler occupied the secretaryship.

The minutes of the 371st meeting were read and approved.

A motion was carried appointing the last three past presidents as a committee on elections, or Messrs. Burnet, Nipher and Meier.

The paper of the evening on "The Graphical Representation of the Output and Efficiency of Operation of a Dynamo" was then read by Prof. F. E. Nipher, who stated that all of the quantities involved can be represented in terms of total E M F magnetizing current and speed. The equation first published by Frolich represents the relation between these quantities in a very satisfactory way in a dynamo, which will run brushes at a practically constant lead. This equation is

$$e = \frac{a\ n\ i}{1 + b\ i}$$

where a and b are constants of the machine.

These constants are easily determined, by determining a series of

simultaneous values of e, n and i through the range of speed and current which the machine will permit. Putting the equation in the form

$$\frac{n\,i}{e} = \frac{1}{a} + \frac{b}{a}\,i$$

and plotting i with the corresponding value of $\frac{n\,i}{e}$, the values $\frac{1}{a}$ and $\frac{b}{a}$ can be taken from the diagram and a and b can be found.

The equation is the equation of a hyperbolic paraboloid, upon which lines of constant output, and constant efficiency, and constant torque can be drawn. The speaker showed how to draw projections of all these lines on the co-ordinate planes of e, i, e, n and i, n, any two of which enables one to clearly see what the dynamo would be able to do under any permissible conditions of operation.

The paper was discussed by Messrs. Seddon, Olshausen, Hermann, Humphrey, Wheeler and Johnson.

Prof. Johnson made an informal report for the committee on quarters.

Club then adjourned. H. A. Wheeler, Sec'y, pro tem.

373rd. Meeting, December 7, 1892. The club met at 8 p. m. at the club rooms, President Johnson in the chair; thirty-six members and three visitors present.

The minutes of the 372nd. meeting were read and approved.

The Executive Committee reported the doings of their 137th meeting.

The Committee on Local Data reported that the material was ready for publication, and recommended that it be published. On motion, the secretary was instructed to proceed with the printing of 1000 copies of the report, and to have enough bound for the members and other uses of the club.

Mr. Burnet stated that the Committee on Roads were not ready to report, and asked to be continued. On motion the committee was continued.

Mr. Burnet reported for the Committee on Permanent Quarters that they expected to be able to make satisfactory arrangements with the Mercantile Club.

Prof. Potter stated for the special committee on change of quarters that they were not ready to report.

On motion both committees on quarters were continued.

The secretary presented the following annual report.

To the Members of the Engineers' Club of St. Louis.

Gentlemen:—The records of the club show the following statistics for the past year: Eighteen meetings have been held, seventeen at the club rooms and one at Washington University. President Burnet occupied the chair at one meeting, President Johnson at sixteen, and Vice-President Crosby at one. The total attendance of members was 532, or an average attendance of twenty-nine. We have also had with us fifty-eight visitors. The total number of meetings is now 372. Eighteen papers were presented by the following members: Profs. Woods, Johnson, Brown, Howe, Potter and Nipher, and Messrs. Burnet, Flad, Farnham, Johnson, Burgess, Moore, Laird, Winslow, Hermann, Crow, Bryan and Colby. The club has lost seven members by resignation. Fourteen new members have been elected and one reinstated. The present roll of the club shows that that we now have 136 resident members and forty-nine non-resident and one honorary member, and three elected but not yet qualified.

Respectfully submitted,

Arthur Thacher.

The treasurer made the following report:

Cash balance from last report		$323 08
Dues, receipts from last report		118 00
" " issued for 1892		1,585 00
" " " new members		233 00
World's Fair assessment		40 00
Whitman library subscription		47 00
		$2,376 08
Vouchers paid	$1,325 75	
Dues, receipts canceled	77 00	
" " on hand	401 00	
Cash balance	572 33	
		$2,376 08

CHAS. W. MELCHER, Treas.

On motion the report was accepted and referred to the Executive Committee to be audited.

The Committee on Nominations reported the following nominations for officers for 1893:

For President—Robert Moore.

For Vice-President—B. L. Crosby.

For Secretary—Arthur Thacher.

For Treasurer—Chas. W. Melcher.

For Librarian—R. E. McMath.

For Directors—{ J. B. Johnson, Geo. H. Pegram.

For Members of Board Managers—{ J. B. Johnson, J. A. Laird.

On motion the report was accepted and the names declared in nomination.

Mr. J. A. Ockerson was nominated as a candidate for member of the Board of Managers.

The Secretary read the formal invitation of the General Committee of engineering societies, Columbian Exposition, inviting foreign engineering societies to make use of the engineering headquarters.

On motion the Executive Committee were instructed to arrange for an informal supper at next meeting.

Mr. B. J. Arnold then read the paper of the evening on "The City Electric Railway Power Station of Little Rock, Ark., and its Record." The road was constructed in 131 days, including 32 days lost in Sundays and on account of rainy weather, or making 99 actual working days. During this time the entire system of about twenty miles of road was either taken up and new rails and ties laid or the track narrowed from broad to standard gauge.

At the power station there were 1000 cubic yards of solid slate excavated, over 1,000,000 brick laid, 333,000 feet of lumber erected on the structure and 1000 horse power of engines, boilers and condensing machinery put in place during this period.

The questions governing the location of the power house and the obstacles met with were discussed. At certain seasons of the year the river water is exceptionally bad and special filters were necessary.

Some of the special features of the power house are: First, the general idea of the building on a hillside. Second, the utilization of a short story for a pit room under all the cars. Third, providing for a washing pit under each track. Fourth, placing the line shafting on top of the partition walls. Fifth, the location of the car barn on top of the power house.

Sixth, the placing of a summer theatre on top of the structure. Seventh, inclining the tracks for convenience in case of fire.

A full set of lantern slides illustrated the general construction and details.

A number of tables showing the cost of fuel and power used were exhibited. The tables showed a very low cost for power.

The paper was discussed by Messrs. Schaub, Potter, Flad, Colby, Seddon, Bouton, Kinealy and Wheeler.

Prof. J. B. Johnson's paper on "The Bearing Resistance of Metallic Rollers as Determined by Experiment," was read by title.

Adjourned. ARTHUR THACHER, Secretary.

374TH. MEETING, DECEMBER 21, 1892. The club met at 7 p. m. at the Mercantile Club. President Johnson in the chair and thirty-nine members and one visitor present. After partaking of a supper the results of the election of officers for 1893 was announced. The following were declared to be elected:

President—Robert Moore.

Vice-President—B. L. Crosby.

Secretary—Arthur Thacher.

Treasurer—Chas. W. Melcher.

Directors—J. B. Johnson and Geo. H. Pegram.

Librarian—R. E. McMath.

Members Board of Managers, Association of Engineering Societies—J. B. Johnson and J. A. Ockerson.

President Johnson, with a few appropriate remarks, relinquished the chair to the newly-elected president, Mr. Robert Moore. After thanking the club, President Moore called on the retiring president for an address. Prof. Johnson gave an interesting address on the "Engineering Profession." The paper pointed out the growth of the profession and gave a number of interesting and valuable suggestions.

Discussion followed, which was taken part in by Messrs. Meier, Nipher, Maxon, Winslow, Crosby, Ockerson, Eayrs, Flad and Condron.

For the next meeting a discussion of Mr. Colby's paper on the "Recent Survey of St. Louis" was announced.

Adjourned. ARTHUR THACHER, Secretary.

ENGINEERS' CLUB OF MINNEAPOLIS.

Regular Meeting was held at the Public Library, Minneapolis, Dec. 8th., 1892. President Pike in the chair.

Minutes of preceding meeting read and approved.

A letter was read from the General Committee of Engineering Societies, Columbian Exposition, with reference to foreign societies and the invitation of same to the World's Fair. The proposed plan was approved.

Prof. Hoag was permitted to bind the Transactions of the A. S. of C. E., and keep same at University of Minnesota, subject to the call of the Club.

Mr. Geo. Andrews and Mr. Fred Llewllyn were proposed for membership, seconded by A. B. Coe and F. W. Cappelen.

Mr. Cappelen read a report upon the recent trip to West Superior, Du-

luth and the Vermillion Range. Said report was ordered upon the Journal as minutes.

A committee consisting of Elbert Nexsen, Geo. W. Sublette and A. B. Coe was appointed to draw up a set of resolutions to express the thanks of the club to the Engineers at the head of the Lake for the hospitality shown our club on the trip in November.

The committee reported and the following resolution was adopted, ordered printed, and sent to each gentleman above referred to.

Minneapolis. Minn., December, 8th., 1892.

Resolved, that the thanks of the Engineer's Club of Minneapolis be extended to:

Eben F. Wells,	West Superior Steel & Iron Co.
S. S. Cooper,	City Engineer. West Superior, Wis.
D. A. Reed.	City Engineer, Duluth. Minn.
Robert Angst.	Chief Engineer, D. & I. R. R.. Duluth.
T. Owens.	Superintendent. D. & I. R. R., Duluth.

and the other engineers of West Superior and Duluth for the very hospitable manner in which the members of this club were entertained on its trip of Nov. 11th. and 12th., 1892, to West Superior, Duluth and the Vermillion Range.

That those who participated will long remember with pleasure this trip, and hope that in the near future an opportunity will be given to reciprocate their kindness.

Elbert Nexsen }
G. W. Sublette } Committee.
Alfred Coe }

F. W. Cappelen, Secretary.

Upon motion the meeting adjourned.

F. W. Cappelen, Secretary.

WISCONSIN POLYTECHNIC SOCIETY.

21st. Meeting. November 14. 1892. 10 members and 8 guests present. Mr. Goodhue in the chair. Minutes of the previous meeting were read and approved. The secretary reports on a communication received from Prof. Chas. D. Marks. Palo Alto. California. requesting his resignation from membership on account of his absence from Wisconsin. Granted.

A letter from the Engineers Club of St. Louis was read proposing the exchange of membership by the following amendment to the By-Laws.

Exchange of Members:—Any member of any Society in the Association of Engineering Societies, in good standing. may become a member of this club, when duly elected as described in Section 7, without paying the initiation fee and with a release from the annual dues for such period not over one year as he may show by certificate he has paid in advance in the society from which he comes, provided such society shall have conferred like privileges to members of this club."

It is moved to vote on the amendment at the next meeting after duly notifying the members by letter. Motion is carried. Mr. Goodhue then presents a letter received from a friend travelling abroad, which comments on the masonry of ancient and modern Rome. The discussion thereby started, is taken part in by Messrs. Koch, Poetsch, Mavrocordato, Scholtka, Spalding, Tucker.

Adjourned. M. J. Schinke, Secretary.

22nd. Meeting, December 12. 1892. 10 members present; 7 guests. Mr. Benzenberg in the chair. Minutes of the previous meeting were read and approved.

Vote was taken on the following amendment to the By-Laws as an addition to Sec. 6, Art. III.

"EXCHANGE OF MEMBERSHIP: Any member of any other society in the Association of Engineering Societies in good standing, may become a member of this society, when duly elected without paying the initiation fee, and with a release from the annual dues for such period, not over one year, as he may show by certificate he has paid in advance in the society from which he comes, provided such society shall have conferred like privileges on members of this society."

The amendment was unanimously carried.

The next business in order was Mr. Rau's paper on "Ancient Rome and its Principal Buildings." With the aid of photographs of the Panorama of Rome at Munich, Germany, Mr. Rau guides the audience, sight-seeing through the streets of that famous city. By his detailed knowledge and graphic descriptions he creates an impression that he is quite at home in Ancient Rome. The value of the paper was acknowledged by applause and a vote of thanks to the author.

M. G. SCHINKE, Secretary.

WESTERN SOCIETY OF ENGINEERS.

297TH. MEETING, DEC. 7, 1892. The 297th. meeting of the Society was held at the rooms of the Central Traffic Association, The Rookery, Wednesday evening, Dec. 7th. 1892, at 8 p. m. President Randolph in the chair and fifty members present.

The minutes of the last meeting were approved.

The Secretary reported for the Board of Directors the election to membership of Messrs. Ralph Modjeski and Wm. Steyh.

The following applications were also filed: Messrs. Oliver Johnson Westcott; Hiram D. Hallett; Albine L. Grandy; Granville Kimball; J. A. Lewis; Wm. McKenzie Hughes, James Wallace Beardsley; George Albert Masters; Andrew Renick Benson; Dorsey Ash; Irving Hitz; Albert Clare; Frank Seymour Baillie; Arthur Douglas Mott; E. D. Miller.

The Directors had carefully considered the necessity of providing funds to meet the inevitable calls upon the hospitality of the Society during the Columbian Exposition, and decided to ask for pledges for contributions for that purpose from the membership.

Messrs. Scherzer, Harding and Mead were appointed a Committee to count the ballots for Amendments of Constitution and By-Laws:

On Amendments of Sections 1 and 2 of Article III of Constitution, the vote gave 112 Ayes, 4 Nays.

Section 1, Article 3 of By-Laws: 115 Ayes, 3 Nays.

Section 7, Article 6 of By-Laws: 115 Ayes, 3 Nays.

Sections 5 and 6, Article 9 of By-Laws: 115, Ayes, 3 Nays.

The President declared the Amendments adopted.

For the Committee on "Badge, Seal," etc., Mr. G. A. M. Liljencrantz read a report recommending the selection of one of three designs and suggesting a course to be pursued to settle the question and supply the badges.

Mr. J. C. Des Granges moved that the recommendations of the Committee be concurred in, that the various designs be engraved and sent out with the Proceedings and that the notice be printed on the ballot for election of Officers. Seconded and carried.

Mr. Aug. W. Wright then read his paper on "Continuous Rails."

The interesting paper was discussed by Messrs. Appleton and Randolph.

The Secretary then read a second paper by Mr. C. H. Hudson, "On a Practical Test of Compound Locomotives in Regular Service."

The paper described another year's actual tests of Compound Locomotives—being a continuation of the eleven months tests described by him in the first paper presented to the Society on October 7, 1891.

Remarks were made by Prof. Arthur T. Woods and Mr. A. C. Harding.

The papers will be given in the JOURNAL OF THE ASSOCIATION as early as possible.

The President reminded the members that the Annual Election of Officers was drawing near, and that it would be necessary in accordance with Article 9, of the By-Laws, to have the nomination petitions presented to the Board by the time prescribed therein.

On motion adjourned. JOHN W. WESTON, Secretary.

ANNUAL SUMMARY.

It is proposed to furnish, in this department, as complete an Index as may be of current Engineering Literature of a fragmentary character. A short note will be appended to each title, intended to give sufficient information to enable the reader to decide whether or not it is worth his while to obtain or consult the paper itself. The Index will be mostly limited to society and magazine articles, and special engineering reports of general interest and value. It is printed in the monthly issues of the JOURNAL, *on but one side of the paper, so that the titles may be cut out and pasted on cards or in a book, and is here collected with additional cross references.*

LIST OF PERIODICALS INDEXED.

Age of Steel (*Age of Steel*), weekly, Equitable Building, St. Louis, Mo.; per year, $3.

American Architect (*Am. Arch.*), weekly, Ticknor & Co., 211 Tremont street, Boston, Mass.; single copy, 15 cents.

American Journal of Railway Appliances (*Am. Jour. Ry. Appli.*), monthly, World Building, New York; per year, $2. single copy, 25 cents.

American Machinist (*Am. Mach.*), weekly, 96 Fulton street, New York; per year, $2 50; single copy, 15 cents.

American Manufacturer and Iron World (*Am. Mfr.*), weekly, Pittsburg, Pa.; per year, $4; single copy, 10 cents.

Annales des Ponts et Chaussees (*Annales des P. & C.*), monthly, Vve. Ch. Dunod, 49 Quai des Augustins, Paris, France.

Electrical Review (*Elec. Rev.*), weekly, 22 Paternoster Row, London, E. C.; per year, 21s. 8d.; single copy, 4d.

Engineering Record (*Eng. Rec.*), weekly, 277 Pearl street, New York; per year, $5; single copy 12 cents.

Engineering News (*Eng. News*), weekly, Tribune Building, New York; per year, $5; single copy, 15 cents.

Engineering and Mining Journal (*E. & M. Jour.*), weekly, 27 Park Place, New York; per year, $4; single copy, 10 cents.

Engineering (*Lon. Eng.*), weekly, London, England; per year, $10; single copy, 25 cents.

Indian Engineering (*Ind. Eng.*), weekly, Calcutta, India; 18s. per year; single copy 8 annas.

Journal of the Association of Engineering Societies (*Jour. Assn. Eng. Soc.*), monthly, 51 Lakeside Building, Chicago; per year, $3; single copy, 30 cents.

Journal of the Franklin Institute (*Jour. Fran. Inst.*), monthly, Franklin Institute, Philadelphia, Pa.; per year, $5; single copy, 50 cents.

Journal of the New England Water Works Association (*Jour. N. E. W. W. Assn.*), quarterly, New London, Conn.; per year, $2; single copy, 75 cents.

Journal of the Society of Arts (*Jour. Soc. Arts*), weekly, London, England; single copy, 6d.

Locomotive Engineering, (*Loc. Eng.*), monthly, 9-12 Temple Court, New York; per year, $2; single copy, 20 cents.

Mechanics (*Mechanics*), monthly, 907 Arch Street, Philadelphia, Pa.; per year, $1; single copy, 10 cents.

Paving and Municipal Engineering (*Pav. & Munic. Eng.*), monthly, Municipal Engineering Co., 44 Chamber of Commerce, Indianapolis, Ind.; per year, $2; single copies, 25 cents.

Power (*Power*), monthly, 113 Liberty Street, New York; per year, $1; single copy, 10 cents.

Proceedings American Institute of Mining Engineers (*Proc. A. I. M. E.*), 13 Burling Slip, New York; per year, $5.

Proceedings of the Engineers' Club of Philadelphia (*Proc. Eng. Club Phila.*), quarterly, 1122 Girard St., Philadelphia, Pa.; per year, $2.

Proceedings of the Institution of Civil Engineers (*Proc. Inst. C. E.*), 25 Great George St., Westminster, S. W. London, Eng.

Proceedings of the Society of Arts (*Proc. Soc. Arts*): Mass. Institute of Technology, Boston, Mass.

Proceedings of the United States Naval Institute (*Proc. U. S. N. I.*), quarterly, United States Naval Institute, Annapolis, Md.; per year, $3.50; single copy, $1.

Railroad and Engineering Journal (*R. R. & Eng. Jour.*), monthly, 45 Broadway, New York; per year, $3; single copy, 25 cents.

Railroad Gazette (*R. R. Gaz.*), weekly, 73 Broadway, New York; per year, $4.20; single copies, 10 cents.

Railway Review (*Ry. Rev.*), weekly, The Rookery, Chicago, Ill.; per year, $4.

Scientific American Supplement (*Sci. Am. Sup.*), weekly 361 Broadway, New York; per year, $5; single copy, 10 cents.

Scientific American (*Sci. Am.*), weekly, 361 Broadway, N. Y.; per year, $3.

School of Mines Quarterly (*Sch. Mines Quart.*), Columbia College, New York City; per year, $2; single copy, 50 cents.

Street Railway Journal (*St. Ry. Jour.*), monthly, World's Building, New York; per year, $4; single copy, 35 cents.

Street Railway Review (*St. Ry. Rev.*), monthly, 265 Dearborn st., Chicago, Ill.; per year, $2; single copy, 25 cents.

Technology Quarterly and Proceedings of the Society of Arts (*Tech. Quart.*), Mass. Inst. Technology, Boston, Mass.; per year, $3.

The Electrical Engineer (*Elec. Engr.*), monthly, 11 Wall Street, New York; per year, $3; single copy, 30 cents

The Electrical World (*Elec. World*), weekly, 177 Times Building, New York; per year, $3; single copy, 10 cents.

The Engineer (*Lond. Engineer*), weekly, London, England; per year, $10; single copy, 25 cents.

The Engineering Magazine (*Eng. Mag.*), monthly, World Building, New York; per year, $3; single copy, 25 cents.

The Inland Architect and News Record (*Inland Arch.*), monthly, The Inland Publishing Co., 19 Tribune Building, Chicago; per year, $5; single copies, 50 cents. Photo-gravure Edition; per year, $10; single copy, $1.

The Irrigation Age (*Irrigation Age*), weekly, Salt Lake City, Utah; per year, $2.

The Locomotive (*Locomotive*), monthly, Hartford, Conn.; per year, 50 cents.

The Mechanical World (*Mech. World*), weekly, Manchester, England; per year, 8s. 8d.; single copy, 1 penny.

The Newspaper Agency, 19 Spring Gardens, London, England.

The Railway Engineer (*Ry. Eng.*), monthly, 8 Catherine St., Strand, W. C., London, Eng.; single copy, 1 s.

The Railway Master Mechanic (*Mast. Mech.*), monthly, "The Rookery," Chicago Ill.; per year, $1; single copy, 10 cents.

The Street Railway Gazette (*St. Ry. Gaz.*), monthly, Phœnix Building, Chicago; per year, $2; single copy, 25 cents.

Transactions American Society of Civil Engineers (*Trans. A. S. C. E.*), 127 East Twenty-third street, New York; per year, $10.

Transactions American Society of Mechanical Engineers (*Trans. A. S. M. E.*), 12 West 31st Street, New York.

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